YOUR GUIDE TO THE GEOLOGY OF
THE KINGS GAP AREA

John H. Way

Environmental Geology Report 8
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# Your Guide to the Geology of the Kings Gap Area, Cumberland County, Pennsylvania

PENNSYLVANIA GEOLOGICAL SURVEY
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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT
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Arthur A. Socolow, State Geologist

# PREFACE

South Mountain of south-central Pennsylvania represents the northern terminus of the well-known Blue Ridge Mountains of Virginia and Maryland. These tree-covered lands provide abundant beauty, color, variety, and mystery for all who enter their bounds. Within this setting, hawks and eagles soar across autumn's clear blue sky, tiny bursts of yellow, blue, and white wildflowers dot the fresh spring meadows, and turkeys and deer move noiselessly over a winter's blanket of newly fallen snow. Yet, day by day, ever so slowly and inconspicuously, these mountains, which seemingly always have been and forever will be, are being worn away. Grain of sand follows grain of sand on an extremely slow journey to the sea. Someday, these grains could be raised again to form new mountains, as were the grains of sand from ancient beaches that we see today in South Mountain.

The shape of the land, each rock formation, the water that springs forth from the ground, every fossil and mineral—each of these has something to tell us about the history of the planet we call home. They tell us of mighty events—earthquakes and floods, landslides and volcanoes. They also tell the story of lowly worms and other creatures that lived in a sea 600 million years ago and of their quiet emergence onto the land. Much more recently, we see through written records how human history has been tied to and shaped by this land. And, predictably, the earth and its resources will continue to play a dominant role in our lives and in those of the generations that follow.

This booklet has been planned to guide you to several points of local geological interest. Each has been selected to illustrate one or more topics within the broad spectrum of geology. By visiting these localities, you can reach back in time and stand where once an ancient river flowed, where once there was a sea floor covered with organisms, and where we can now see the effects of former collisions between continents. These are all pieces of the geologic puzzle, and you have the opportunity to study each dramatic episode in the quietly unfolding story of the earth.

When you travel about, please do not be satisfied with those things that can be seen from your car window or along the roads. Step off the pavement and onto the soil; explore an area or find a trail, an easy task in the state forests and parks. Poke in the dirt, pick up a rock, search for a fossil, watch grains of sand move in a freshet after a rainstorm. Experience the land firsthand.

And do not be satisfied with what you find in this volume either; this is only the appetizer. If your curiosity is piqued by what you see or if there is something you do not understand, use the resources listed on page 31. Go to a library, college, museum, or historical society, or come to the Pennsylvania Geological Survey. Ask a teacher, naturalist, or geologist a question.

But most importantly, examine this fragile world of ours. Discover its strengths and weaknesses. Marvel at its vast splendor and find out how this magnificence came to be. Seek out its scars and determine how they got there. Study the natural and human systems, each delicately balanced, highly complex, and totally interdependent. This world belongs to all of us. It's our home. Learn all you can about it—it's the only one we will ever have.

*   *   *

*Kings Gap Environmental Education Center, in south-central Cumberland County, is approximately 25 miles southwest of Harrisburg, 9 miles south-southwest of Carlisle, and 2 miles east-southeast of Huntsdale (see centerfold map for local detail).*

Environmental Geology Report 8

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by **John H. Way**
Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY
FOURTH SERIES
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**1986**

# 1. GEOLOGY—SOMETHING FOR EVERYONE

Nearly everyone at some time has passed display cases in a museum and marveled at the delicate crystals and colorful minerals. Most of us have picked up pebbles from the beach or an interesting rock or fossil. And, how often have we stopped to take advantage of a breathtaking view at a scenic overlook. All of these remind us of nature's beauty.

But rocks may not provide these same pleasures to a bulldozer operator who must dig deeply for a foundation where bedrock occurs close to the surface. Nor are we happy when a detour takes us far out of our way because a sinkhole or landslide has closed the road. And, when our well goes dry, there will probably be considerable inconvenience and expense to remedy the situation.

In one way or another, we are constantly being reminded of our physical environment, whether it is from headlines that broadcast news of the latest natural disaster, or the less dramatic, yet none-the-less significant, request from a neighbor to sign a petition against allowing a quarry to expand its operation near our home. These examples underscore the interrelationship between ourselves and our home, the earth.

*Everything* we use, except sunlight, comes from the earth, and it is through geology, the science that specializes in the study of the earth, that we come to understand this sphere of rock that carries us safely on our journey through space, and without which we could not exist (Figure 1-1). It is therefore important that we explore and attempt to understand this world of ours. The Kings Gap Environmental Education Center was established for just this purpose. It serves very well as a base from which we can venture forth into nature's laboratory and make observations, collect samples, ask questions, and propose answers, all of which are important parts of the science of geology.

The succeeding chapters involve many of the specialized fields that are covered under "geology," including stratigraphy, structural geology, geomorphology, hydrogeology, economic geology, sedimentology, mineralogy, and paleontology. Some of these fields have been specifically mentioned and defined, whereas others are only touched upon. However, the emphasis has been placed on what you, the observer, can see after being given a few hints as to what to look for and where to find it. The main topics examined in each chapter are summarized below.

Chapter 2: Major features such as mountains, valleys, plains, and plateaus do not start or stop at state borders, park boundaries, or other man-made lines. The landforms around Kings Gap are segments of those crossing the eastern half of North America.

Chapter 3: Scenery observed from a single vantage point comprises an assemblage of landforms. Those landforms are the result of a variety of geologic processes acting on rocks over a period of time. The view from Kings Gap mansion focuses attention on these interactive processes.

Chapter 4: Exposures of a rock unit called the Antietam Formation provide an excellent opportunity to examine quartzitic rocks in some detail. The small quarries that provided stone for the mansion are still visible.

Chapter 5: Springs are relatively uncommon, especially in most urban settings, yet they can be found scattered throughout the South Mountain area. Two springs, each in a different geologic setting, are examined.

Chapters 6 and 7: The mines and charcoal furnaces in the South Mountain area contributed significantly to Pennsylvania's status as an iron-producing center in the colonial period.

Chapter 8: Climb along a fault zone to reach the top of Pole Steeple, another excellent quartzite exposure, and compare this rock with that seen at Kings Gap.

Chapter 9: Hammonds Rocks is an exposure of conglomerate of the Weverton Formation, one of the oldest sedimentary rock units in the state. At this site, it is possible to view the area from Blue Mountain to the York Valley.

Chapter 10: Observable outcrops of volcanic rocks are limited to just a few places within the southeastern part of the state. The Catoctin Formation metarhyolite, exposed near Laurel Forge Pond, is a metamorphosed volcanic rock with some relict volcanic textures.

Chapter 11: Wherever a significant volume of a pure mineral occurs in nature, it is likely to have some economic value. The quartz vein capping the hillside north of Pine Grove Furnace is one such deposit.

Chapters 12 and 13: Economic geology also plays a role in both the sandstone borrow pit south of Pine Grove Furnace and the mining operation at Toland. The multiple-mining history—first iron, then clay, now aggregate—is an additional interesting facet of the Toland mine.

Chapter 14: Not only are the region's iron ore pits of historical interest, but they also attract mineral collectors seeking unusual minerals from unique geologic settings.

Chapter 15: The generalized geologic map and cross section show the distribution of the rock units in the South Mountain area and some of the structural complexities, such as folds and faults, within this region.

References and additional sources of information have been included for those who wish to pursue subjects only lightly touched upon in this volume. This list is brief, and there are many other geological resources available—do not hesitate to seek them.

Figure 1—1. Oceans and continents, among the earth's largest features, are only visible in views such as this from space. The photograph on the back cover shows details of mountains and valleys, smaller, yet nonetheless significant structures. Figures throughout this booklet depict outcrops, still smaller crustal features. Field investigations of individual outcrops such as these provide scientists with information to speculate about how the larger features came into being. (Photograph courtesy of the National Aeronautics and Space Administration.)

# 2. AN OVERVIEW OF PENNSYLVANIA'S LANDSCAPE

The cumulative effects of all of the geologic processes that have operated over the last 4.6 billion years have given our world a landscape of exceptional diversity, complexity, and beauty. Attempting to describe the major features of the earth systematically, *geomorphologists,* those scientists who study landforms, have defined *physiographic provinces* based on the shape, continuity, uniformity, and geologic durability of landforms. These provinces serve to describe easily recognizable segments of the landscape.

The physiography of the 48 contiguous states consists of eight major divisions. The eastern United States is dominated by three divisions, and parts of each are present in Pennsylvania: the *Atlantic Plain* (AP), the *Interior Plains* (IP), and the *Appalachian Highlands* (AH) (Figure 2-1).

PENNSYLVANIA PHYSIOGRAPHY: The Atlantic Plain comprises two provinces: onshore, the *Coastal Plain,* a narrow band of which is present in the extreme southeast around Philadelphia; and offshore, beyond Pennsylvania, the submerged *Continental Shelf.*

The *Central Lowland* province is present in Pennsylvania as a narrow band bordering Lake Erie. This lowland is a part of the Interior Plains division, which includes the entire central portion of North America.

Most of Pennsylvania lies in the Appalachian Highlands division. It is a composite of highly varied topography underlain by many geologically complex terranes. The five provinces included in this division are arranged in roughly parallel, northeast-southwest-trending belts (Figure 2-2). From southeast to northwest they are as follows:

(1) *Piedmont:* a nonmountainous upland underlain by metamorphosed and deformed igneous and sedimentary rocks. Also included is the *Mesozoic Lowlands* section, a structural basin mostly filled with red, Triassic sedimentary rocks. Igneous diabase ("ironstone") intrusions form ridges both inside and outside the basin.

(2) *Blue Ridge* (South Mountain): a major fold structure, containing faulted and metamorphosed igneous and sedimentary rocks. It extends from Pennsylvania southwest to Tennessee.

(3) *New England* (Reading Prong): the prominent highland extending southwest from Connecticut and ending in eastern Pennsylvania near Reading. It consists of a series of tightly folded and thrust-faulted structures, producing ridges underlain by igneous and metamorphic rocks, and smaller valleys containing limestones and shales.

(4) *Valley and Ridge:* a region comprising two sections. The *Appalachian Mountain* section is the wide belt of long, continuous linear ridges and intervening valleys underlain by a thick sequence of folded and faulted sedimentary rocks. The broad lowland to the southeast, the *Great Valley* section, is covered with fertile fields and underlain by intensely folded and faulted limestones and shales. Caves and caverns are numerous throughout this valley that stretches from New Jersey to Tennessee.

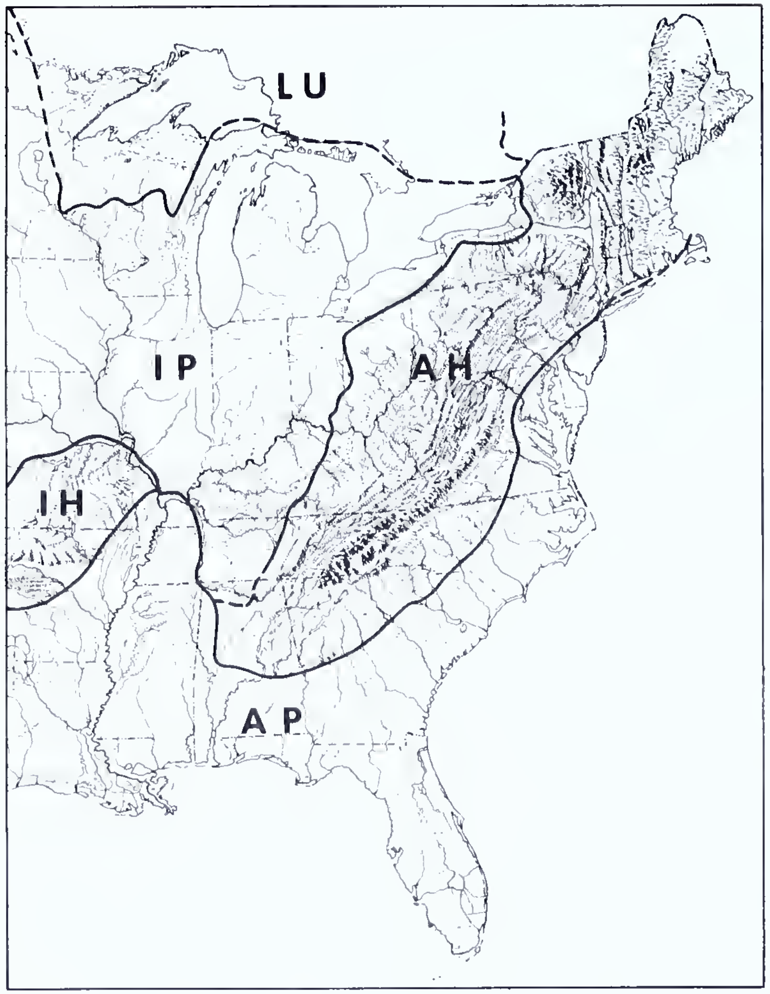
(5) *Appalachian Plateaus:* an upland of flat-topped mountains and deep valleys; a rugged topography of significant relief. Gentle folds and minor faults become more prominent to the southeast. Throughout the province, however, the sedimentary rock layers are gently dipping to horizontal.

LANDFORMS AND GEOLOGY: Landforms reflect the variations among the rocks and geologic structures. The topographic profile across South Mountain (Figure 2-3) helps in the understanding of this cause-and-effect relationship between geology and the local landscape.

The topographic break on the northwest side of South Mountain is sharp. The mountain front descends steeply to the floor of the Great Valley. Although the fold structures of South Mountain persist across the valley, the strong contrast in topography results from the significant difference in the way the adjacent rock types have weathered and eroded. The carbonates and shales of the Great Valley are much less resistant to weathering than the South Mountain quartzites; hence the low elevations and low relief of the valley.

Farther northwest, the Blue Mountain front defines the boundary between the Great Valley and the Appalachian Mountain sections. Folded, quartz-rich sedimentary rock units underlying Blue Mountain, and others beyond, are strongly resistant to weathering and erosion. Valleys between the ridges contain rock types similar to those of the Great Valley, resulting in a comparable lowland topography.

To the southeast, the lack of a topographic contrast between South Mountain and the Mesozoic Lowlands in the profile is deceiving. Topographic variations appear minor, yet there is a marked geologic difference between these physiographic regions. The Mesozoic Lowlands section has low relief, a result of the uniform weathering and erosion properties of its gently inclined sedimentary rocks. Folded and faulted metamorphosed quartzites, much more resistant to weathering and erosion, produce the high elevations and high-relief topography of South Mountain.



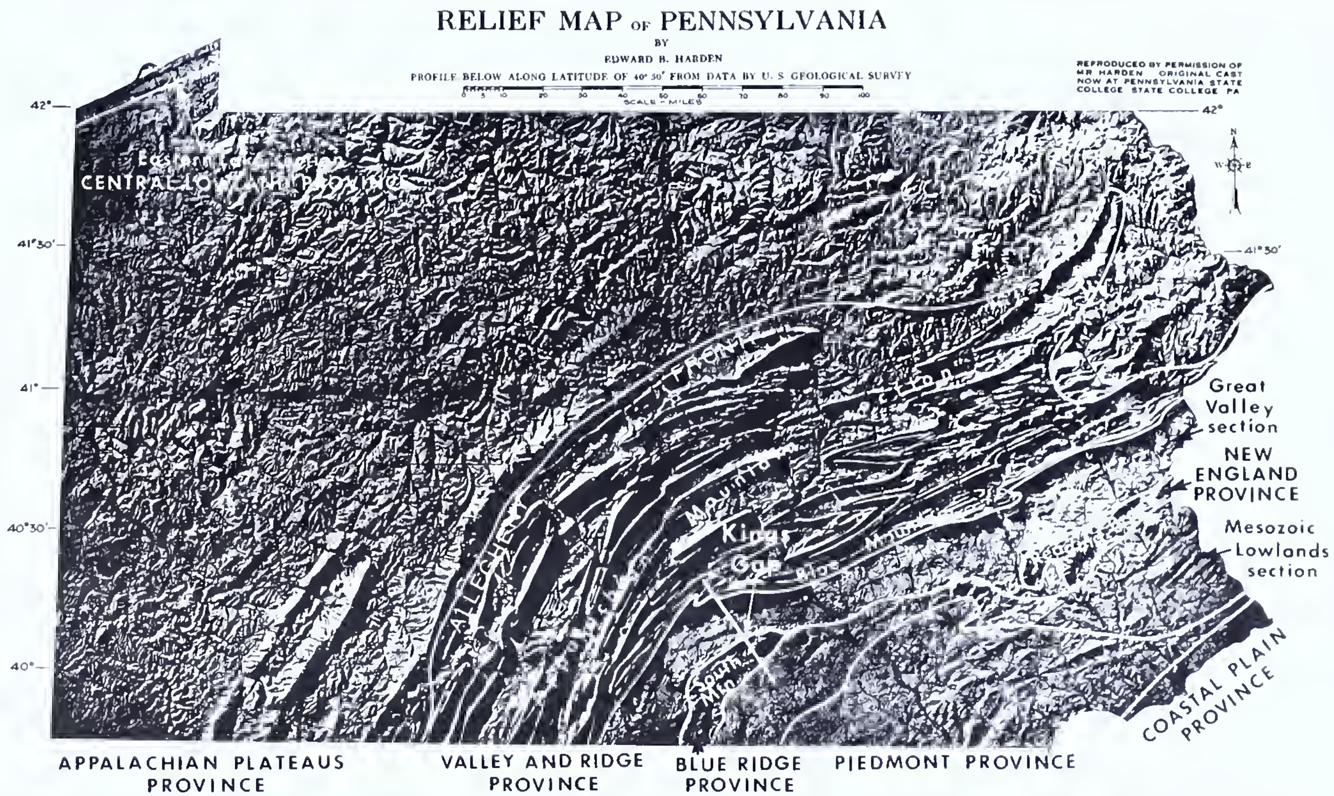




Figure 2–2. Shaded relief map of Pennsylvania with major physiographic provinces and sections delineated. Kings Gap and the line of the topographic profile in Figure 2–3 are shown.

◄ Figure 2–1. Physiographic divisions of the eastern United States. Atlantic Plain (AP), Appalachian Highlands (AH), Interior Highlands (IH), Interior Plains (IP), and Laurentian Upland (LU) are outlined (base map from Erwin Raisz, U.S. Geological Survey, 1970, p. 59; divisions after Fenneman, 1938).

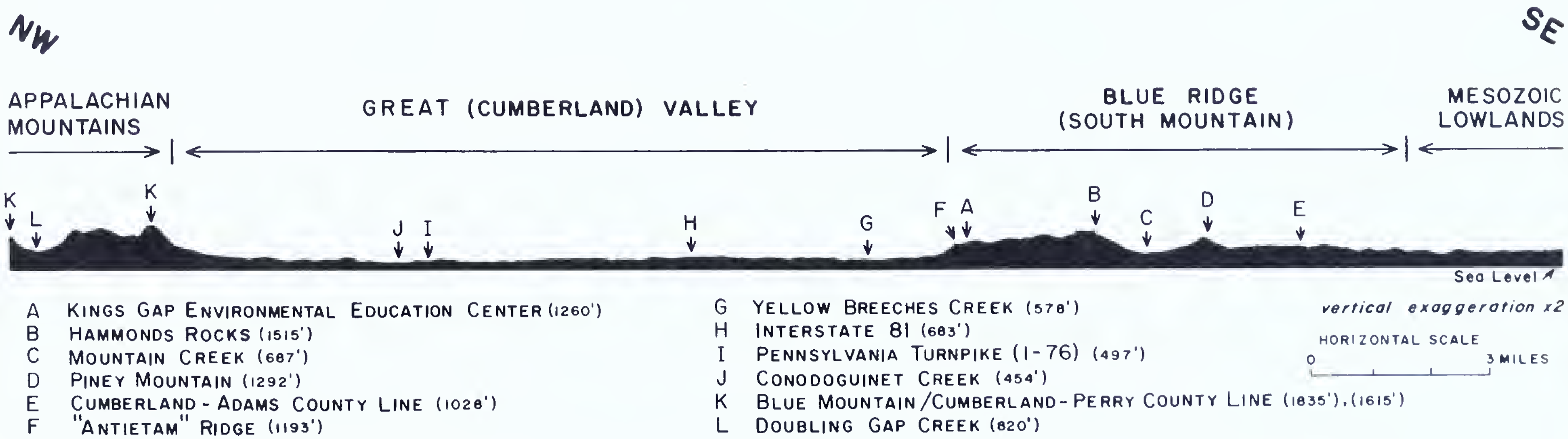



Figure 2–3. A topographic profile drawn through Kings Gap and the nearby physiographic provinces (see Figure 2–2; centerfold map). From Kings Gap (A) on the northwest edge of the Blue Ridge province, an observer can look across the Great Valley to Blue Mountain (Valley and Ridge province). To the southeast, the Mesozoic Lowlands (Piedmont province) can be seen from atop Hammonds Rocks (B).

# 3. VIEW FROM THE MANSION TERRACE

From the base of South Mountain, the Kings Gap complex lies completely hidden from view. It sits about 650 feet higher on the mountain's edge (3 on centerfold map). A narrow and winding entrance road climbs 4 miles through Kings Gap Hollow, providing the traveler with glimpses of rock outcrops, a stream valley with boulders and sparkling waters, and even an occasional deer wandering through the oak and pine woods that are complimented with stands of mountain laurel, rhododendron, bracken, and wild blueberries.

A sharp right turn near the summit brings signs of human habitation into view. The two-story caretaker's house and maintenance garage, formerly a stable and carriage house, are situated to the left of the drive. Opposite, on the right, are the generator building and ice house. Finally, the roofed entranceway, supported by two thick stone columns, and the massive, ivy-covered native-stone walls of the main house appear (Figure 3-1). This structure, often referred to as the "mansion," gives the appearance of a remote fortress, reminiscent of a bygone era.

A BIT OF HISTORY: Kings Gap was built as a summer home by James McCormick Cameron, the grandson of Simon Cameron, a prominent figure in local and national politics. Like his father and grandfather, James Cameron became a successful businessman, with interests in coal, steel, lumber, railroads, and real estate.

James Cameron began acquiring land in Cumberland County in 1904, and by the following year, he owned 46 tracts totaling more than 2,700 acres. It took three to four years to complete the road and buildings at Kings Gap, and Cameron used these facilities until 1946. In 1951, the C. H. Masland and Sons Carpet Company of Carlisle purchased the home and nearly half the land of the original estate. The company maintained the property as a guest house and meeting center for 20 years. In 1973, the Department of Environmental Resources purchased Kings Gap for one-half its assessed value (the remaining half was donated by the Maslands), and four years later the Kings Gap Environmental Education Center opened. As it was 75 years ago, Kings Gap remains one of the largest and most picturesque estates in the entire Cumberland Valley.

THE VIEW TO THE WEST: From the flagstone patio at the rear of the mansion (Figure 3-2), a visitor is greeted by a magnificent view across the Cumberland Valley. Under ideal conditions, the visibility is greater than 25 miles, and many points of interest can be easily identified (Figures 3-3 and 3-4).

The most prominent feature appearing on the horizon stretches almost completely across the field of view. This linear ridge, called Blue Mountain, is the southernmost ridge in the Valley and Ridge province. It is underlain by the Tuscarora Formation, a geologic rock unit well known for quartz-rich sandstone beds that display extreme resistance to weathering and erosion.

Looking to the northwest, V-shaped folds in the rocks in Blue Mountain (back cover) account for Doubling and McClures Gaps. Waggoners and Sterretts Gaps, to the north, are small notches in the ridge crest compared to the deep cut northwest of Shippensburg, McAlisters Gap, which permits the Conodoguinet Creek to flow into the Great Valley from the west.

The 12-mile-wide lowland separating Blue Mountain from South Mountain is the Great Valley, locally called the Cumberland Valley. Within this valley, the rounded hills of low relief in the distance contrast with the broad, flat to gently rolling topography closer to South Mountain (our viewpoint). The difference in rock types beneath these two terranes and the way in which the rocks weather account for the variations in topography.

Shales, siltstones, and sandstones of the Martinsburg Formation underlie the far side of the valley. These rock types, moderately resistant to the forces of mechanical weathering and surface erosion, support the tree-covered hills.

Carbonate rock formations, mostly limestone and dolomite, occur beneath the intensely farmed lands on the near side of the valley. Here, chemical weathering processes dominate. Circulating water slowly dissolves the rock, resulting in underground solution channels, sinkholes, and a general lowering of the land surface, all characteristic of carbonate terranes in humid climates.

Rising from the valley floor toward our vantage point at the mansion is the tree-covered ridge in the foreground. It is underlain by a tough, resistant quartzite rock called the Antietam Formation. Quartzite blocks, naturally weathered and broken away from the ridge, along with rock quarried from pits developed in the south side of the ridge, were used as the building stone for the mansion and surrounding structures. Drill holes, such as those that can be seen in blocks in the mansion walls (Figure 3-5), remain as evidence of the quarrying process.

The Antietam ridge is interrupted by gaps in many places. Kings Gap Hollow is one of these. Gaps are presumed to form in zones of highly fractured or faulted rocks. Zones of broken rock tend to be weaker and more susceptible to the forces of mechanical and chemical weathering. Thus, permeability is likely to be higher, and the greater volume of water passing through these zones removes rock material and widens any openings that exist. Downcutting and headward erosion by stream action further expand these zones of weakness.

◄ Figure 3–1. A curved driveway sweeps by the stone canopy entrance to the ivy-covered Kings Gap mansion, the focus of activities for the Environmental Education Center.

Figure 3–2. Perched on the mountain's edge, the Kings Gap mansion appears as a remote fortress. The flagstone terrace at the rear of the mansion allows for an expansive view of more than 120 degrees across Cumberland Valley toward Blue Mountain. ►

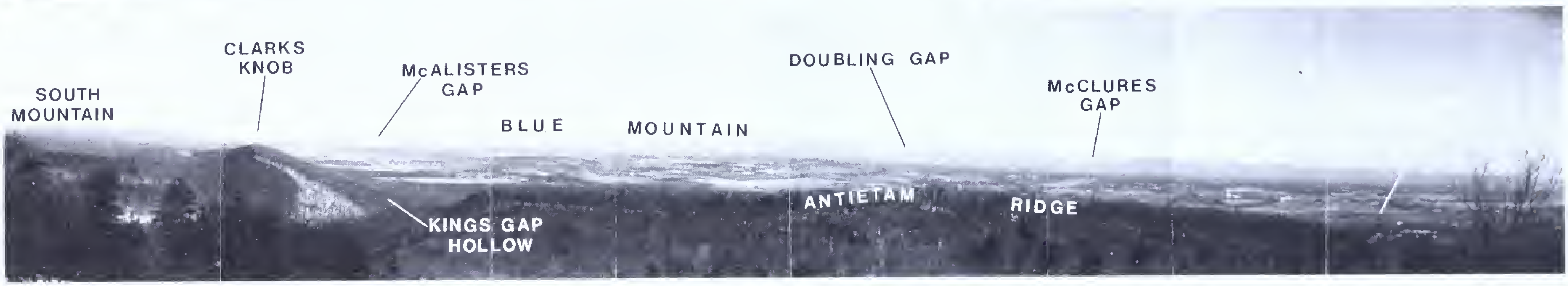
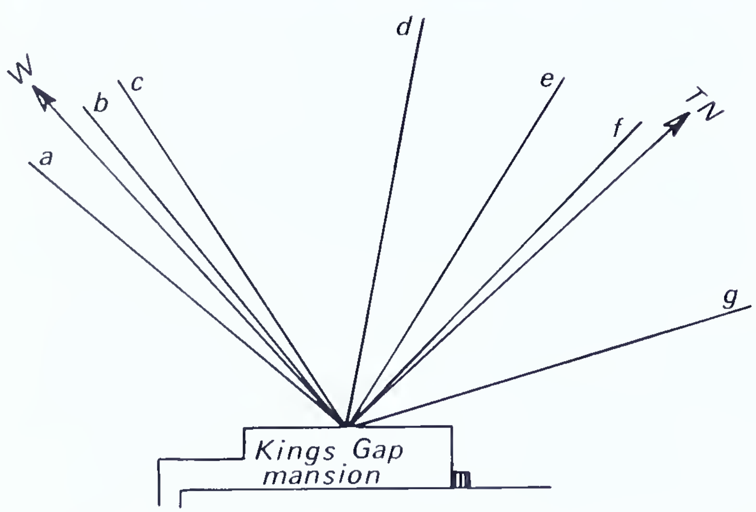



Figure 3–3. A panorama as seen from the mansion.




| | azimuth | distance (miles) |
|---|---|---|
| *a.* Clarks Knob | 264° | 26.0 |
| *b.* McAlisters Gap | 275° | 22.0 |
| *c.* Pa. Turnpike Tunnel | 281° | 20.5 |
| *d.* Doubling Gap | 324° | 15.0 |
| *e.* Mc Clures Gap | 345° | 13.5 |
| *f.* Waggoners Gap | 358° | 12.5 |
| *g.* Sterretts Gap | 027° | 15.5 |

Figure 3–4. Points visible along Blue Mountain from Kings Gap. The azimuth given for each of these points is based on true north (TN) as being 0 degrees (or 360 degrees) and west (W) as 270 degrees. Magnetic north is approximately 8 degrees west of true north.

Figure 3–5. Holes in a quartzite block in one arched doorway entrance at the back of the mansion were drilled by hand, one step in the quarrying operation.

# 4. THE ANTIETAM QUARTZITE ALONG RIDGE AND ROCK SCREE TRAILS

LOCATION: Parts of Ridge and Rock Scree Trails complete a loop that crosses the ridge crest and circles back along its base (Figure 4–1; 4 on centerfold map). This loop is about 1.2 miles long and begins near the mansion.

BE A FIELD GEOLOGIST: This is a perfect opportunity for you to climb over outcrops, examine the rocks and, in addition, learn some of the things a geologist does in the field. Field geologists gather information from natural outcrops, such as the ones seen along the ridge, as well as man-made exposures such as roadcuts, railroad cuts, quarry highwalls, mines, and tunnels.

A geologist carries some specialized tools and instruments into the field (Figure 4–2A). Imagine yourself putting on boots and buckling your belt from which hangs a geologic hammer, a pocket transit (Figure 4–2B), a small plastic bottle containing dilute hydrochloric acid, and a field case that holds a notebook, pencils, and ruler. Hang a hand lens around your neck, grab the all-important maps and aerial photographs, and let's be off to the rocks along Ridge Trail.

One important rule: Always keep track of your location. Use topographic maps (e.g., Figure 4–1) or aerial photographs. If the outcrops you visit are not plotted accurately, all the data collected from them are meaningless. As you set out, begin to look around and make observations. Note the high, low, and flat parts of the landscape; this all has geologic significance. Of course, reading the topography is also a necessary step in locating yourself.

Look closely at the rock outcrops (Figure 4–3). Pick up a rock fragment and examine the size and shape of the particles; use your hand lens for a magnified image. Try to identify the rock type by determining the mineral components. Look for features or structures that distinguish sedimentary rocks from metamorphic rocks. If the rocks in an outcrop are arranged in layers, these layers might represent *bedding,* the primary depositional surfaces. Otherwise they are probably secondary (formed after deposition), possibly as a result of regional metamorphism.

The orientation of planar bedding and fracture surfaces, called the strike and dip, is another piece of data that geologists collect. For this task, a specialized type of compass called a pocket transit (Figure 4–2B) is used. These data are plotted on the geologic map and help the geologist understand the structure of the region. In addition, photographs and neat, labeled sketches of prominent features, drawn to scale, aid in the understanding of the outcrop.

OUTCROP SPECIFICS: A few brief points about these exposures:

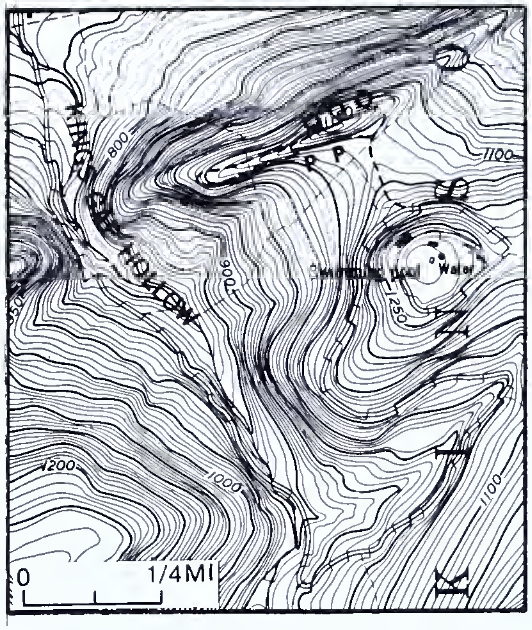
(1) *Rock type:* The Antietam Formation is predominantly very resistant quartzite made up mostly of quartz grains held together by quartz cement. A photograph of the quartzite, as seen through the microscope (Figure 4–4), shows the interlocking nature of these quartz grains. Texture of this type suggests that the rocks may have been put under a great amount of pressure, thereby forcing the grain boundaries to fit very tightly together. This kind of pressure was probably associated with the metamorphism that accompanied the folding and faulting of the rocks in this region.

(2) *Structure:* Here, along the western edge of South Mountain, the beds of the Antietam Formation are nearly vertical. Sedimentary rocks such as these were originally deposited horizontally. About 290 million years ago, they were rotated from that original horizontal position by the crustal forces responsible for producing South Mountain and the Appalachian Mountains.

(3) *Trace fossils:* The long, narrow tubes filled with sediment are the infilled dwelling burrows of marine worms. These burrows, called *Skolithos* (Figure 4–5), commonly occur in clusters oriented perpendicular to the bedding surfaces. They may be seen in many quartzite outcrops and loose blocks found throughout the South Mountain area.

(4) *Building-stone pits:* Along the southeast side of the ridge, several small indentations interrupt the natural slope (Figures 4–1(P) and 4–6A). These are the sites of the quarrying operation that provided building stone for the Kings Gap mansion and surrounding structures. Small cylindrical holes in the quartzite bedrock in these pits (Figure 4–6B) provide further evidence of man-made workings. These holes, 3 to 5 inches deep and 6 to 8 inches apart, were first drilled in the rock by hand. The rock was then split apart by inserting into each hole pieces of half-round iron, called feathers, the sides of which were curved to fit the hole, and hammering a wedge-shaped plug between them (Figure 4–6C). The broken rock was then loaded onto horse-drawn wagons and carried to the building site at the top of the mountain.

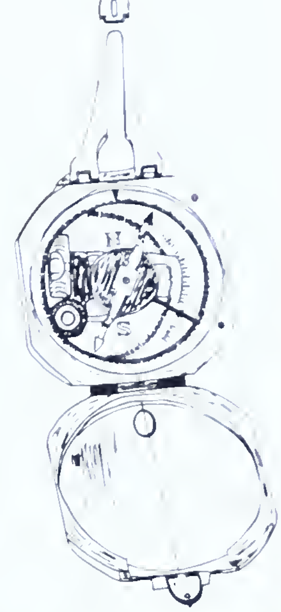
(5) *Scree:* The loose, angular blocks of rock covering the slopes around the ridge exposures are known as *scree.* Scree accumulates as a result of the downslope movement of the rock after it has broken away from an outcrop. Gravity acts to pull the rock debris downhill, and the freeze-thaw cycles that occur during the colder months aid in this process. Vegetation, on the other hand, tends to stabilize surficial deposits, and unless the toe of the deposit is cut, movement of this rock and soil mass is extremely slow.




◄ Figure 4–1. Index map of portions of Ridge and Rock Scree Trails plotted on the Dickinson 7½-minute topographic map (contour interval = 10 feet). Some of the outcrops (O) and quarry pits (P) are marked.

Figure 4–2. A. Typical field geologist in full regalia. B. A pocket transit is used in geological field work primarily for measuring horizontal and vertical angles. ►

A



B

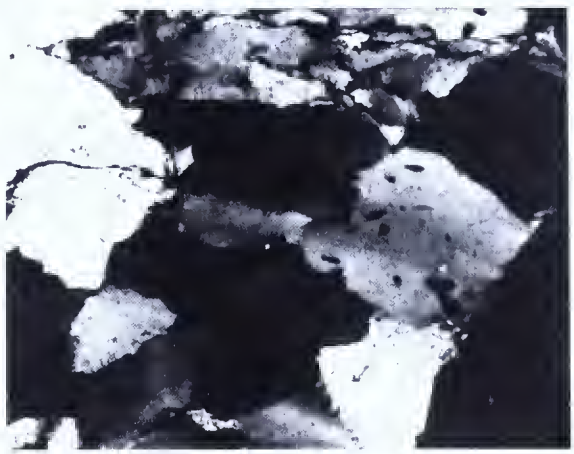
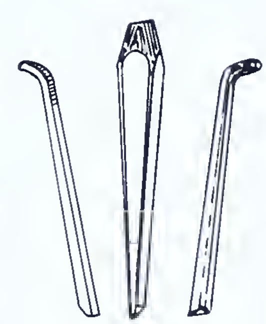


Figure 4–4. Photomicrograph of Antietam quartzite. Nearly all the grains and the cement holding the grains together are quartz. The larger grains range between 0.02 and 0.08 inch in size.

◄ Figure 4–3. Outcrop of the *Skolithos*-rich Antietam Formation on the ridge to the northwest of the Kings Gap mansion.

A


B




C

Figure 4–5. Vertical burrows in the Antietam Formation are the trace fossils *Skolithos*. Sedimentary bedding, perpendicular to these burrows, is the slightly irregular surface shown across the bottom of the photograph. Dime shows scale.

Figure 4–6. A. The sites of quarrying operations that supplied the stone for the structures at Kings Gap appear as obscure indentations cut in the southeastern slope of the ridge. B. Hand-drilled holes in the Antietam Formation still can be seen in some of the rocks in the small quarry pits. C. Iron feathers were inserted in the hand-drilled holes and the rock was split apart when a plug was driven into the space between the feathers.

# 5. WATER—SPRINGS FROM THE GROUND

People have always been fascinated by springs. Springs sustain life and are surrounded with the greenness and freshness of growing vegetation. They give rise to streams. And some believe them to be the cleanest and most attractive water supplies available, although this is not always so.

Many springs occur near Kings Gap on South Mountain and in the Cumberland Valley. Their local prominence is reflected by town names such as Mount Holly Springs, Big Spring, and Boiling Springs. Springs supplied abundant water for the early industries around which many of the colonial towns grew.

Simply put, any opening in the ground surface from which water discharges naturally is a spring. The conditions that produce springs are many and varied. Elements of geology, hydrology, topography, and climate are all factors. We will examine two springs in different settings—one at Huntsdale and the second in the headwaters of Cold Spring Run—to see what happens as water seeps, flows, and springs from the ground.

LOCATIONS: Nine springs supply water to the Pennsylvania Fish Commission's Huntsdale Fish Cultural Station on Pa. Route 233 in the village of Huntsdale (Figure 5-1; 5a on centerfold map). The fish hatchery lies at the foot of South Mountain in the headwaters of Yellow Breeches Creek, at the southern edge of the Cumberland Valley.

Cold Spring (5b on centerfold map) is a major source for Cold Spring Run on South Mountain. Water issues from the ground several feet downslope from a wide pulloff on the west edge of Cold Spring Road. White quartzite pebbles and sand cover the streambed here, standing in stark contrast to the surroundings. This spring is approximately 0.85 mile north of Ridge Road.

GEOLOGY SETS THE STAGE AT HUNTSDALE: The water used to raise fish at Huntsdale comes from South Mountain. Several geologic factors, in combination with each other, allow the water to move down from the mountain and into the valley. These include (1) the rock types, (2) the fault and fracture network in the rocks, (3) the unconsolidated deposits above the bedrock, and (4) the way groundwater moves in this area.

Figure 5-2, a geologic cross section, illustrates what is beneath the surface here. This part of the Cumberland Valley is underlain by carbonate rocks called limestone and dolomite. Bordering the valley on the south, and standing 600 to 800 feet higher, are the quartzite ridges of South Mountain. Covering the ridge slopes and spreading out onto the valley floor are thick, wedge-shaped deposits of rock, sediment, and soil, called colluvium.

HOW THE WATER MOVES: Precipitation falling on South Mountain enters the groundwater system by seeping downward through the interconnected openings between grains of unconsolidated sediment (Figure 5-3A). This water, already naturally acidic, becomes more acidic as it percolates through soils rich with decaying organic matter. After passing through the soil and sediment, it enters a network of fractures and faults in the quartzite (Figure 5-3B). The water moves down through these openings from the mountain to the valley (Figure 5-2).

The carbonate rocks of the Cumberland Valley are mainly made up of the minerals calcite and dolomite, with smaller amounts of quartz, clays, and other minerals. Both calcite and dolomite dissolve when exposed to acidic solutions.

The carbonate rocks, like the quartzites, contain a network of fractures through which water can move. As it does, it slowly dissolves the limestone and dolomite, gradually eroding the bedrock from within. Large solution openings are created (Figure 5-3C), and an insoluble, muddy residue of quartz and clay minerals is often left behind. This process takes many thousands of years, and can result in the formation of caves and interconnected caverns. The top surface of the carbonate bedrock also dissolves from rainwater percolating down directly through the overlying soil. The results of both processes are evident on the surface in the gently rolling topography and, in places, the presence of depressions and sinkholes caused by the collapse of caverns. A benefit of all of this dissolution is the formation of great thicknesses of soil. These soils, rich in mineral matter, make the Cumberland Valley so agriculturally productive.

The conduits carrying the groundwater through the rocks eventually intersect the surface. It is here that water flows from the ground as springs. The carbonate rocks in this area are capable of transmitting very large quantities of water. At Huntsdale, nine springs supply approximately 10,000 gallons of water every minute, nearly 14.4 million gallons per day (Figure 5-4).

COLD SPRING: The cool, clear water bubbling forth at Cold Spring (Figure 5-5) is brought by gravity from the surrounding hills. This is the same mechanism that produces the springs at Huntsdale; however, the geologic setting is a bit simpler. Here, bedrock is close to the surface and there is little sediment cover. The simplest explanation for the spring is that this topographic low spot intersects the water table (Figure 5-6A). There are other possibilities, such as that the water table intersects one or more major fractures, a fault zone, or a contact between two different bedrock units (Figures 5-6B,C,D).

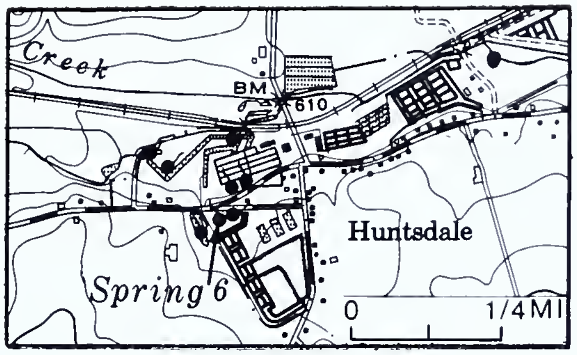



Figure 5–1. Location map of nine springs that contribute over 10,000 gallons of water per minute to the operation of the Huntsdale Fish Cultural Station (after Becher and Root, 1981). Spring 6 is shown in Figure 5–4.

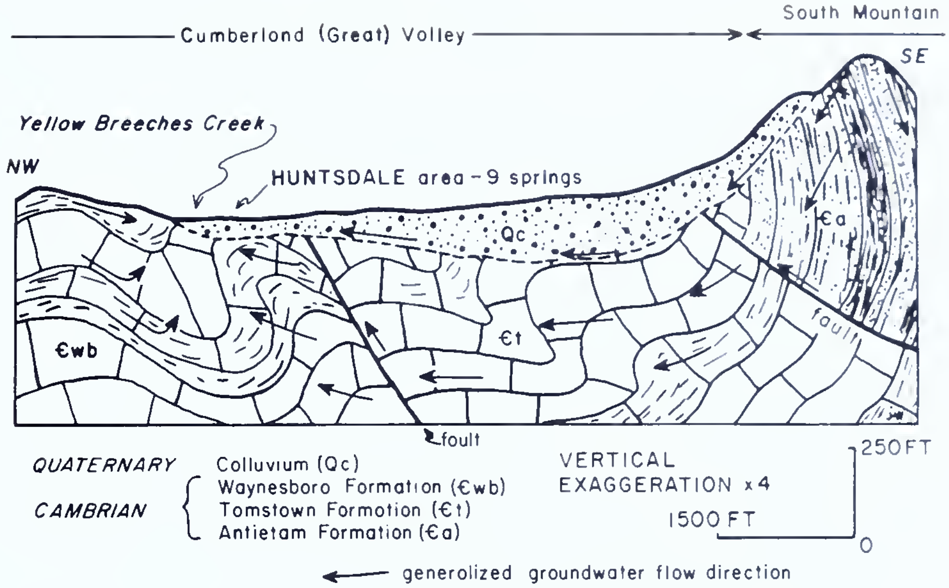
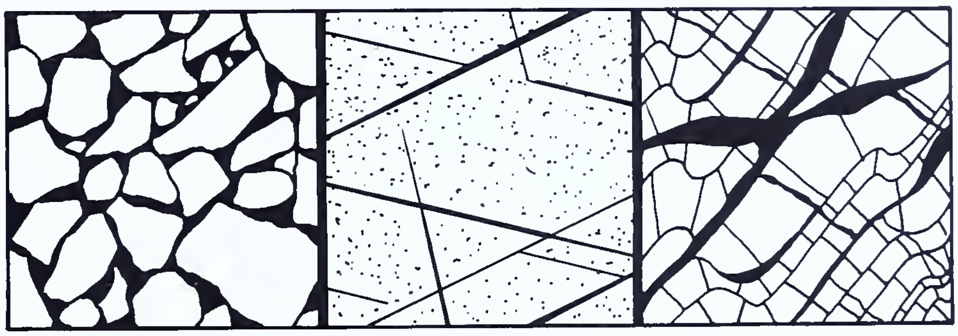


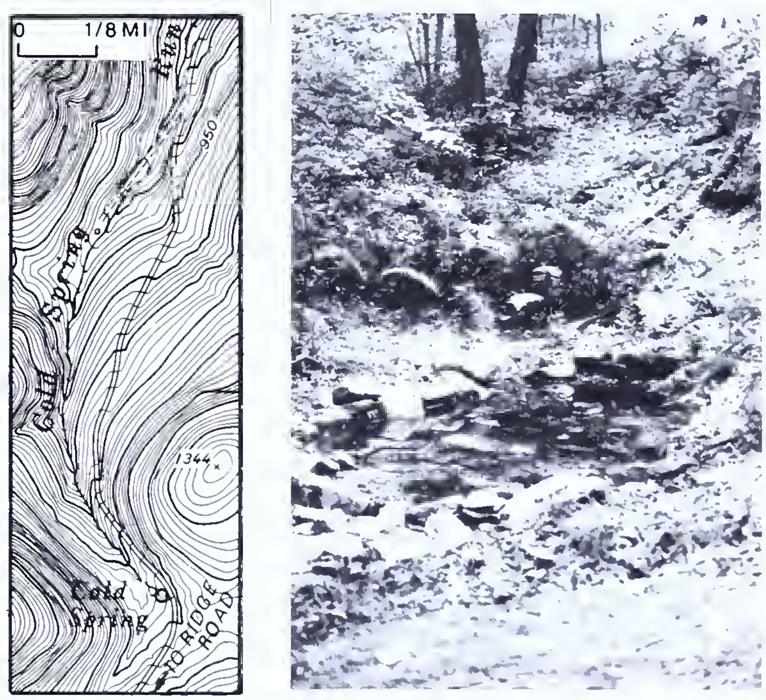

Figure 5–2. Geologic setting for the springs in the Huntsdale area. Cross section is drawn across the Cumberland Valley and South Mountain (see centerfold map for location of cross-section line).



A B C

Figure 5–3. Groundwater is stored in and moves through openings in sediment and rock. A. Open spaces or voids between rock fragments in loose sediment. B. Fractures or cracks allow much water to pass through seemingly solid rock. C. Carbonates, such as limestones and dolomites, often contain solution-widened fractures which permit large quantities of water to move through the rocks.

Figure 5–4. Spring 6, one of the nine springs tapped by the Huntsdale Fish Cultural Station, is easily accessible for observation.




A B

Figure 5–5. A. Location map of Cold Spring, a small spring just downslope from the edge of Cold Spring Road. B. Clear water bubbles forth from Cold Spring and enters Cold Spring Run. This and many other small runs along the northwestern side of South Mountain serve as sources to Yellow Breeches Creek.

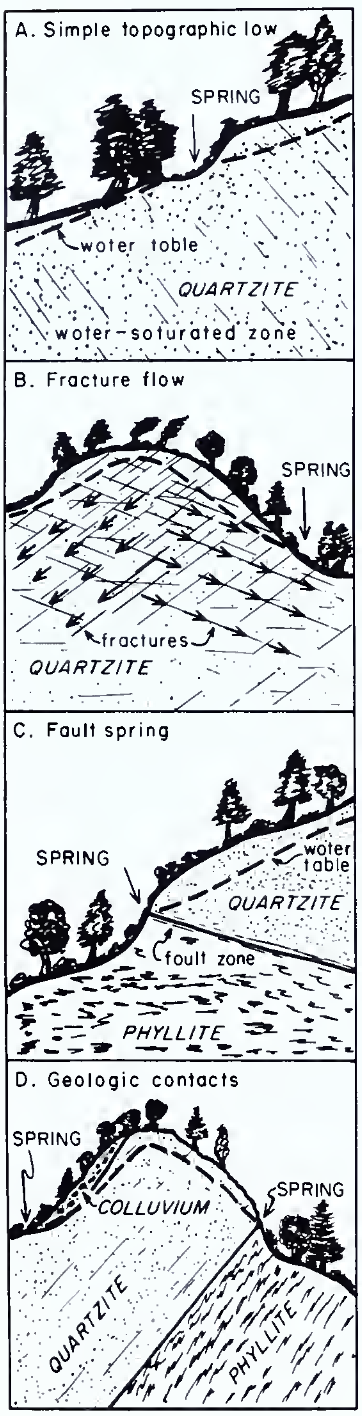



Figure 5–6. Possible geologic settings that could account for Cold Spring and the many springs throughout South Mountain.

# 6. THE EIGHTEENTH-CENTURY IRON INDUSTRY

The roots of the iron-manufacturing industry in the South Mountain region can be traced to the very beginnings of this country. Explorers in the New World reported abundant iron ore and endless forests. Both ore and wood for charcoal were in extremely short supply in England at that time, and the price of iron had risen steadily. So investors looked to the colonies to supply iron in sufficient quantity to breathe new life into a vital, yet faltering, home industry.

The first attempts at iron-making in America were frustrated by Indian attacks, insufficient investor capital, lawsuits, and technical failures. But slowly, small ironworks called "bloomery forges" or "bloomeries," producing crude, brittle metal, evolved into the larger, more sophisticated blast furnaces (Figure 6–1).

Iron was also among the colonists' greatest needs. Farmers required axes, picks, and plowshares; carpenters depended on hammers, planes, and saws; coopers needed hoops for barrels; wheelwrights wanted wheel rims; shipbuilders sought anchors and metal fittings; and of course, housewives needed pots, pans, knives, forks, and spoons, among the endless number of basic implements made from this metal.

Ironworks could not be located just anywhere; ore, limestone, wood, and water were all necessary. The South Mountain area could not have provided this industry with a better setting. Both iron ore and limestone occurred in close proximity and in relative abundance. The surrounding hillsides and valleys were dense with trees yielding a seemingly infinite supply of charcoal, and the spring-fed mountain streams provided more than sufficient waterpower to turn the huge waterwheels that operated the bellows, driving great blasts of air into the furnaces and forges. Let us now turn to those natural resources that made possible this pioneer industry.

IRON ORE: Most of the iron ore mined in this area came from pits or "banks" along the northwest foot of South Mountain and Piney Mountain (Figure 6–2). In the early days of the iron-making industry, it was possible for farmers, working pits on their land, to supply most of the ore that a nearby furnace required. Large trenches or pits were developed, rarely exceeding 40 feet in depth.

The ore itself, referred to as brown-hematite ore or mountain ore, consists mostly of limonite. Limonite, a general term for hydrous iron oxides, assumes a diversity of forms and colors, ranging from brown to yellow, and from dense and hard to light and crumbly.

LIMESTONE: Another basic ingredient of the iron-making process was limestone. This rock, usually quarried near a furnace (6a on centerfold map), acted as a fluxing agent by separating contaminants from the ore. As the iron ore and limestone melted in the furnace, the impurities within the ore floated to the top of the liquid. The melted limestone combined with the nonmetallic impurities, converting them into liquid slag. Every hour or so, a worker raked slag from the surface of the liquid. Today, slag can be found scattered around the furnace sites. It appears glassy, varies greatly in color, and often contains holes.

CHARCOAL: The third vital element in the production of iron was the fuel, and throughout the eighteenth century that fuel was charcoal. In order to produce charcoal, great quantities of wood were needed by the ironmaster. Usually during the winter months, small armies of woodcutters felled trees, cut them into logs of proper length, pulled off the bark, and left them for several months to dry.

"Coaling" the wood required several colliers to build and tend mounds. They began by drawing a circle 30 to 40 feet in diameter, called a pit or hearth, on a dry, level piece of land. After clearing away all the brush, turf, and stones, the mound was constructed, first by building a chimney about a centerpole, and then by arranging the cut wood in a radiating pattern around the chimney in four layers (Figure 6–3). The first and second layers were formed by heavy lengths of wood set in place vertically. The third and fourth layers were lighter pieces laid on top horizontally. Afterwards, all openings were plugged with smaller pieces of wood, and the entire structure was covered with leaves, earth, and sod to make it airtight. A partial reconstruction of such a mound can be seen along Charcoal Hearth Trail at Kings Gap (6b on centerfold map).

Early in the morning on a calm, quiet day, the master collier ignited the mound, and the fire slowly gnawed down through the 10- to 14-foot-high woodstack. The colliers were on a constant state of alert, fearing a sudden gust of wind would generate flames that could quickly turn the pile into useless ashes. Charring required from a week to a month, and when the burning was complete, the charcoal was hauled to a stone charcoal house near the furnace or forge for storage.

A completely burned mound contained from 800 to 1,200 bushels of charcoal, representing 20 to 30 cords of wood. This is equivalent to about 1 acre of forest and 20 to 25 years of tree growth. The amount of charcoal consumed by iron furnaces was enormous. At full capacity, an average furnace used 800 bushels of charcoal every 24 hours, and over the period of a year, could require 240 or more acres of woodland. As a result, many furnaces had to be shut down as the surrounding forests disappeared.

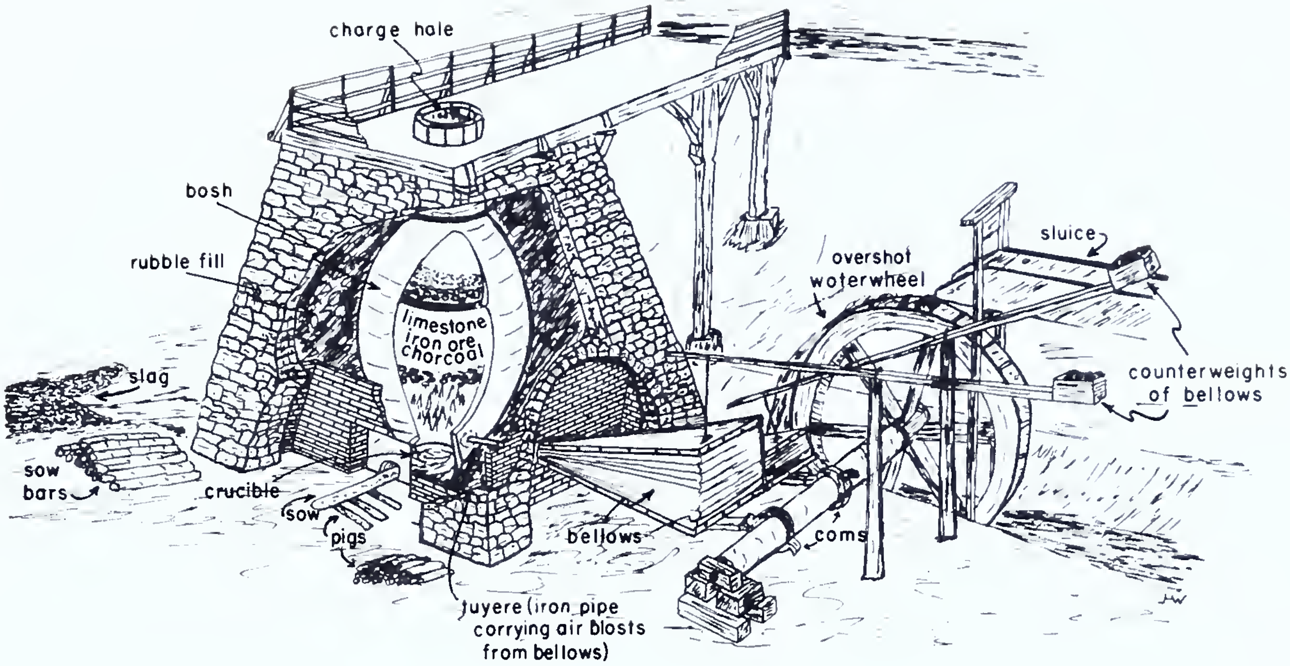



Figure 6–1. Sketch of a typical cold-blast furnace used to manufacture iron in colonial times.

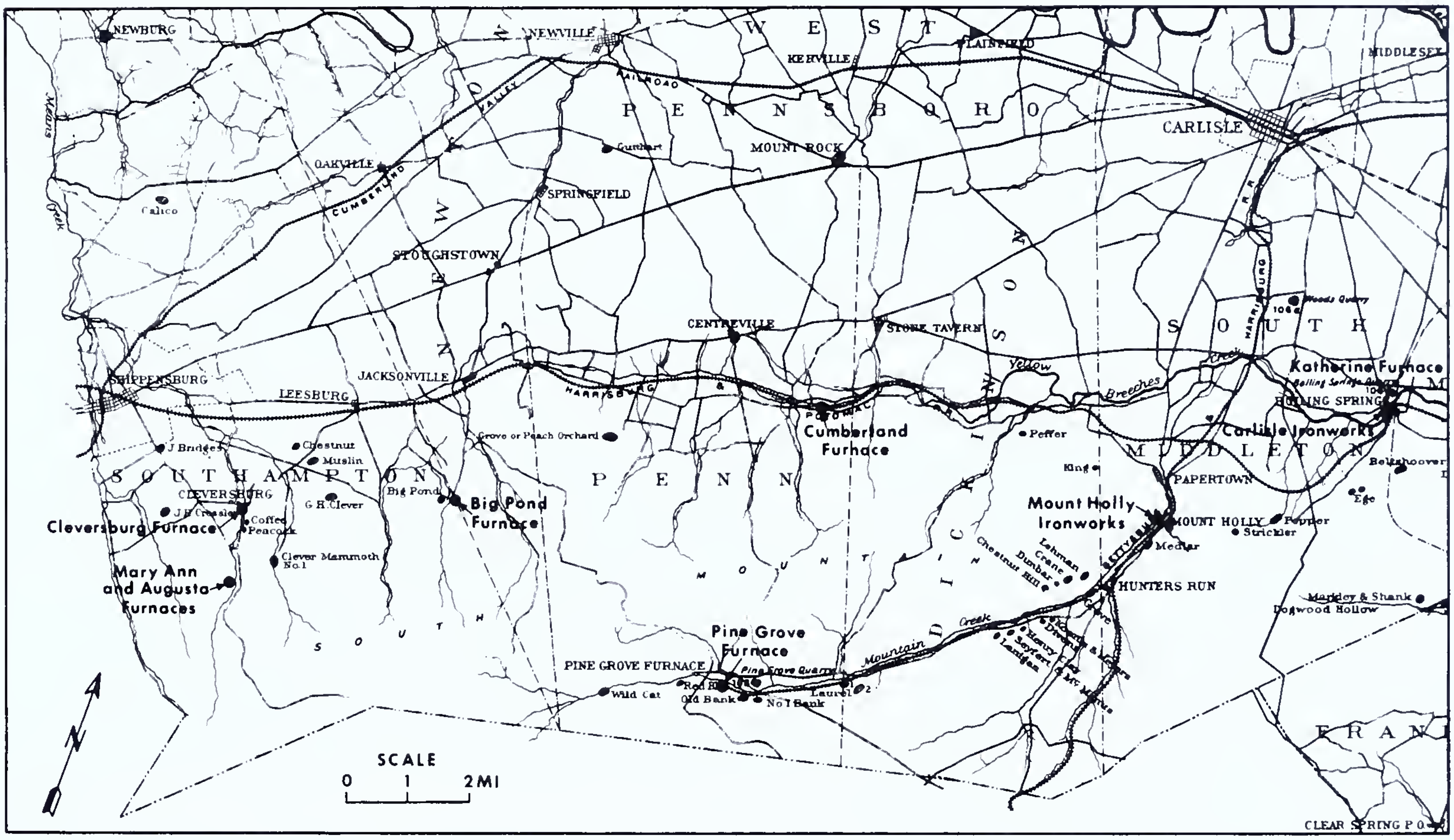



Figure 6–2. An 1886 map of the iron ore mines and limestone quarries within Cumberland County (d'Invilliers, 1887, sheet 8). The locations of eight furnaces have been added.

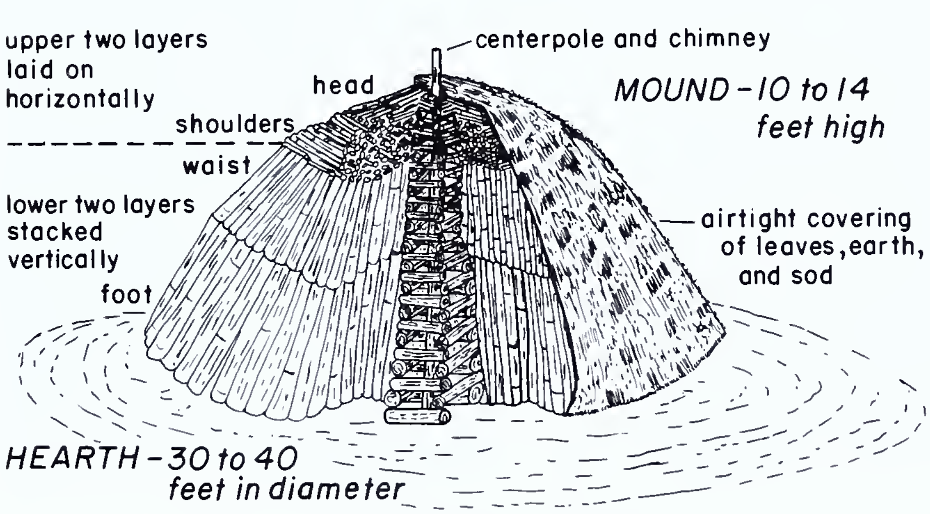



Figure 6–3. Sketch of a wood mound on a hearth that would be "coaled" or burned to produce charcoal to fuel the iron furnaces and forges of the area.

# 7. PINE GROVE IRONWORKS

LOCATION: The site of the Pine Grove ironworks, in Pine Grove Furnace State Park, is nestled in Mountain Creek valley, between South Mountain and Piney Mountain, Cumberland County. Laurel Forge was located near Laurel Forge Pond at the eastern end of the park.

The state park lies south of the town of Pine Grove Furnace, situated at the junction of Hunters Run Road and Pa. Route 233. To the northeast, Hunters Run Road follows the old railroad grade (South Mountain spur of the Gettysburg and Harrisburg Railroad) and Mountain Creek downstream to Mount Holly Springs. To the southwest, Pa. Route 233 continues toward Caledonia State Park, the site of an iron furnace in Franklin County. And to the north, Pa. Route 233 intersects Interstate 81 at Exit 11.

WHAT IS LEFT TO SEE? The relics of the now-vanished colonial iron industry—a few buildings, the stone furnace stack, flooded ore pits, a limestone quarry, and a pit that was presumably the source of liner material for the furnace—provide a glimpse into the past at Pine Grove (Figure 7-1).

One of the two most prominent focal points of this old iron plantation is the large L-shaped building that sits on the hill overlooking the furnace and the rest of the community. Known as the "big house" or "mansion house," this stately and spacious stone building was the home of the ironmaster, his family, and servants (Figure 7-2; 7a on centerfold map). Its rooms were handsomely furnished, its cupboards full of delicate china and glassware, and, on cold winter days, its massive chimneys spewed smoke from the many fireplaces, a sign of the warm hospitality offered to visiting officials. All of this stood as the symbol of the ironmaster's power and wealth for the community below to see.

In stark contrast to the pretentiousness of the "big house," the cottages of the furnacemen, forgemen, miners, and other workers were small and austere, usually constructed of log and plaster. The furnace and forge, a charcoal house, an office, a general store, a gristmill, a sawmill, and a blacksmith shop, all surrounded by fields, orchards, barns, dense woods, and the iron mines, complete the picture of a self-sufficient community, likened by some historians to the feudal manors of medieval Europe.

A wooden fence surrounds the remnants of the furnace stack, all that now remains of the large complex of structures that was the secondmost prominent feature of this community (Figures 7-3 and 7-4; 7b on centerfold map). Pine Grove Furnace, believed to have been built around 1770, proved to be the second of nine blast furnaces in Cumberland County. The first structure on the site was primitive, constructed of local stone. It was similar to other early furnaces in that it was a cold-blast charcoal furnace with one tuyere (the nozzle through which the air blast is delivered to the furnace). The property passed through several owners, each modifying and improving the operation as understanding of the iron-manufacturing process advanced. Prior to its abandonment around 1891, it was once again modified, this time to a hot-blast operation. However, the metal of the future was steel, and small, local operations such as this soon became obsolete.

Near the furnaces, the South Mountain landscape is dotted with craterlike depressions, the remnants of iron ore mining. The largest open-pit operation in the Pine Grove area is filled with water and has become Fuller Lake (Figures 7-1, 7-5, and 7-6; 7c on centerfold map). Smaller ore pits, such as Laurel No. 1 bank (7d on centerfold map) were more typical at the time.

Limestone was quarried from an area immediately south of Fuller Lake (6a on centerfold map). Today, only a few exposures of the limestone are visible around the edges of this large excavation.

Approximately 0.3 mile north of the mansion house, on the northeast side of the paved road, is a pit that was developed in a soft, somewhat greasy feeling rock called "talcose schist" (7e on centerfold map; Figure 11-1A). Old geologic reports of this area indicate that this material was used to line the interior of the furnace. As such, it served as a refractory material, meaning that it resisted the intense heat generated within the furnace and prolonged the life of the structure itself.

LISTEN, SMELL, AND FEEL THE PAST: Even though few physical aspects of this patriarchal, iron-making community have survived the years, a sense of what went on at that time is still with us. Let your imagination carry you back to the eighteenth century as you wander around the Pine Grove area.

Step into the hot and sooty casting shed adjacent to the furnace and watch as molten iron flows from the hearth into sand molds cut into the dirt floor. In the forge, listen to the incessant pounding of the cast-iron hammerheads, weighing several hundred pounds each and moved by huge waterwheels. Listen as metal strikes metal and the forgemen produce an ancony, a thick, flat iron bar with rough knobs at each end. Join the line of workers pushing wheelbarrows, brimming with ore, limestone, and charcoal, to the charge hole belching fire and smoke atop the furnace. Visit the company store to buy some cloth, food, and medicine, and add these to your long list of past charges, bills that may never be fully paid. Or, as you rise at dawn and look out over the valley, see and smell the blue haze that hangs just above the trees, smoke that originates from the charcoal hearths on the mountainsides, from the furnace and forge, and from the chimneys of the houses. You may wonder how any sunlight at all filters down to warm the soil and nourish the seedlings that will be your food supply for the coming year.

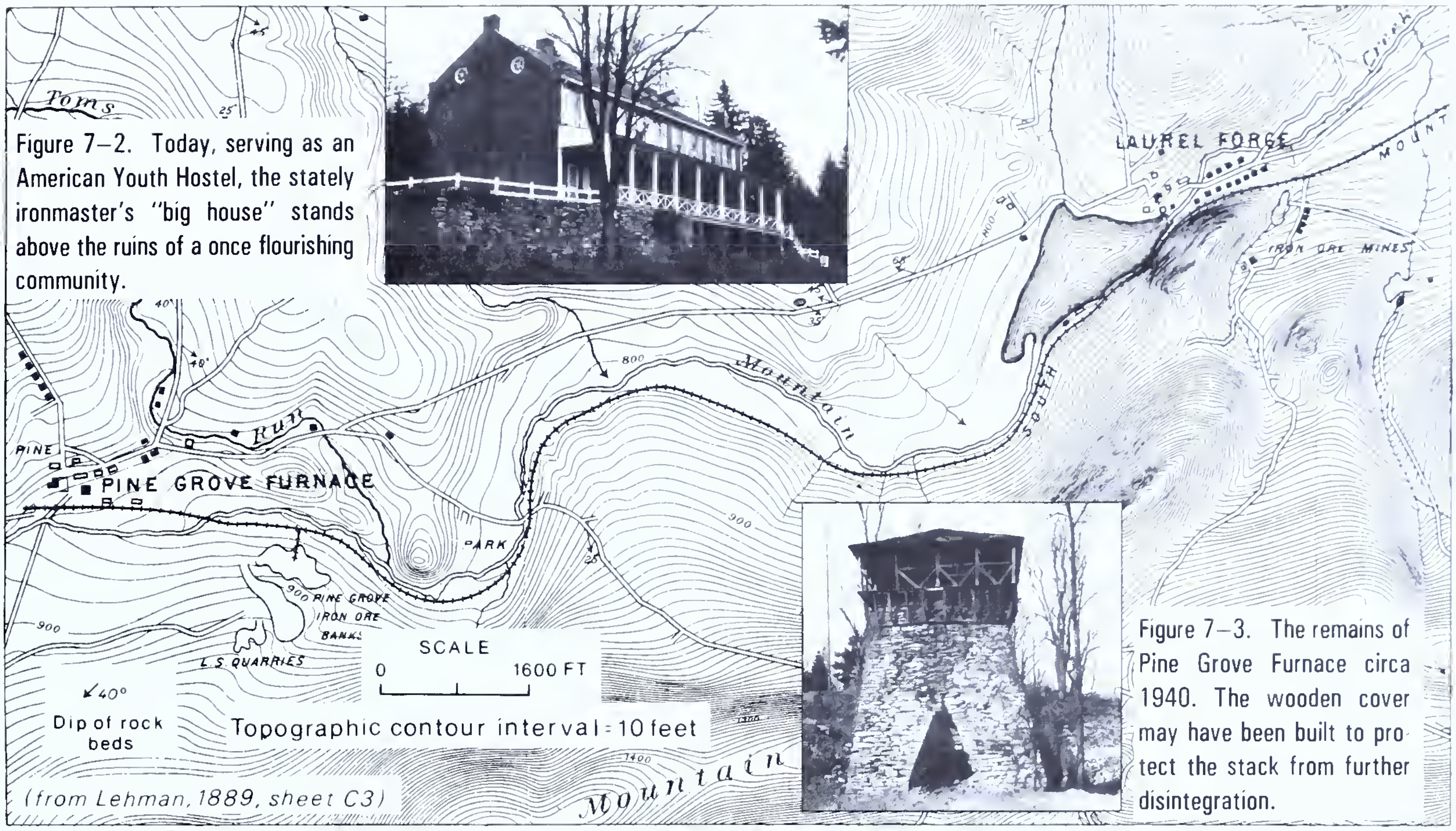



Figure 7–2. Today, serving as an American Youth Hostel, the stately ironmaster's "big house" stands above the ruins of a once flourishing community.

Figure 7–3. The remains of Pine Grove Furnace circa 1940. The wooden cover may have been built to protect the stack from further disintegration.

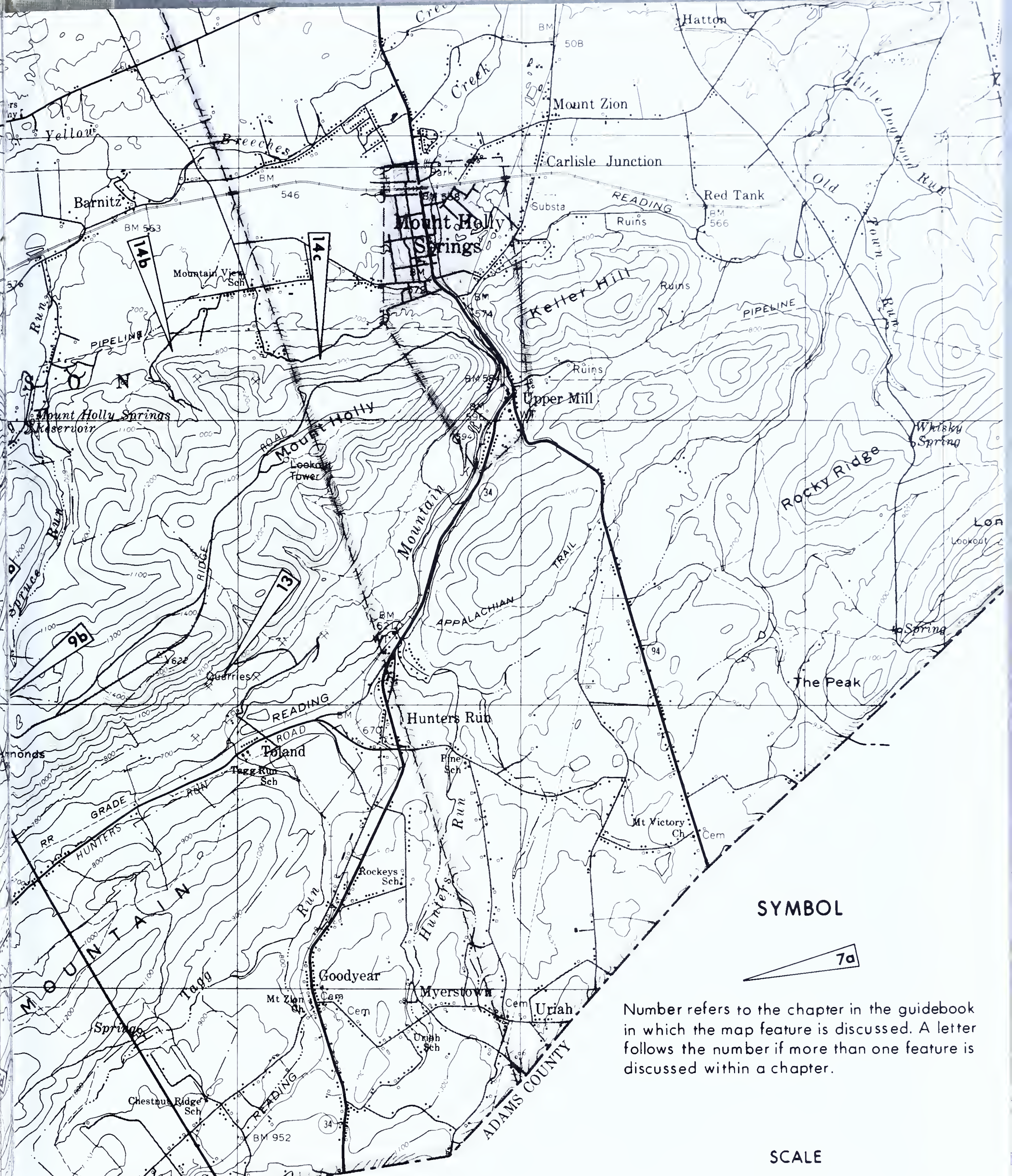
Figure 7–1. A map published in 1889 shows the locations of the ore banks, mines, and quarries serving Pine Grove Furnace and Laurel Forge. The present size and shape of Laurel Forge Pond is not much different than is shown on the map.

Figure 7–4. A northwest view of Pine Grove Furnace circa 1875. The mansion house is in the background on the left. The stone furnace stack in the center is surrounded by buildings. (Photograph courtesy of the Cumberland County Historical Society.)

Figure 7–5. Pine Grove iron ore pit circa 1875. The view is to the northwest. (Photograph courtesy of the Cumberland County Historical Society.)

Figure 7–6. The ore pit today, better known as Fuller Lake, from a northwest view similar to that in Figure 7–5.

Drive-in Theater
Rest Area
BM 638
INTERCHANGE 11
Mooredale
Shady Grove Sch
174
Part of line of topographic profile shown in Figure 2-3
Cumminsville
Cem
Dickinson Ch
Dickinson
Township Sch
Moors Mill
BM 578
BM 587
Hockersville
Longsdorfs Cem
174
233
5a
14a
PINE
ROAD
BM 592
Forest Sch
Montsera
Cem
Creek
BM 623
BM 610
Entrance to Kings Gap
D I C K I
State Fish Hatchery
Longsdorf
BM 630
Huntsdale
PIPELINE
"Antietam" Ridge
3
Breeches
READING
Line of cross section shown in Figure 5-2
P E N N
Grove
BM 685
Brushtown
Ruins
South Fairview Ch
BM 699
4
Gap
Kings
Cold
SPRING
Hollow
6b
Cobblesville
WT
State Road Hol
Kings Gap Environmental Education Center
Spring
Buck Ridge Tower
BM 1077
ROAD
Peach Orchard Hol
Pinnacle Mountain
Chimney Rocks
Betem Hol
RIDGE
BM 1330
9a
S O U T H   M O U N T A I N
233
Line of topographic profile shown in Figure 11-1B
11
10
BM 1021
F O R E S T
C O O K E
Water Tank
Camp Michaux
Sewage Disposal
Toms
Run
7e
Run
Pine Grove Furnace
Laurel Forge Pond
7d
774
Little Rocky Ridge
BM 877
7c
Pole Steeple
7a
Fuller Lake
Creek
APPALACHIAN
TRAIL
8
Big
7b
BM 952
Mountain
12
6a
P I N E Y
BM 1401




## SYMBOL

7a

Number refers to the chapter in the guidebook in which the map feature is discussed. A letter follows the number if more than one feature is discussed within a chapter.

SCALE

0 1/2 MILE

# 8. POLE STEEPLE

LOCATION: Pole Steeple lies almost 2 miles east of Pine Grove Furnace near the southern boundary of Cumberland County with Adams County (8 on centerfold map). Between the Appalachian Trail on Piney Mountain to the south and Mountain Creek valley to the north, these barren pinnacles of quartzite tower more than 525 feet above Laurel Forge Road.

*Caution:* Although this outstanding feature is visited by hundreds of people each year, including busloads of school children, good sense should be exercised. The rock ledges extend to a sheer cliff face, with a near-vertical drop along the northwest side. Leaves and loose rocks are numerous on the trail, and the inclined rock surfaces of the overlook are smooth. Footwear with good tread is recommended.

TRAIL TO THE TOP: A well-blazed trail (with paint marks) to the summit begins near parking areas along the narrow paved road southeast of Laurel Forge Pond (Figure 8-1). The trail, roughly divisible into three parts, cuts 0.5 mile through Piney Mountain's tree-covered slope in Michaux State Forest. The first third of the trail rises at a moderate grade, the middle portion is gently sloped to almost flat in places, and the final third rises steeply, ending in a moderate 60-foot climb up through the rock face itself.

Although it is not visible from the Appalachian Trail, Pole Steeple is also accessible to cross-country hikers of that trail via a short 0.3-mile side trail.

WHAT TO LOOK FOR: On the trail from Laurel Forge Pond to the top, keep an eye out for large, level, circular areas, on the order of 30 to 40 feet in diameter. The trail crosses three, and there are several more in the woods not too far off the trail (Figure 8-2). Look for the dark coloration of the ground, and a lack of large trees and rocks in the area. These circles are the remains of *charcoal hearths,* sites where large piles of wood were burned to produce charcoal for the local iron-making industry during the eighteenth and nineteenth centuries. The charcoal produced here was probably taken to Pine Grove Furnace and Laurel Forge. If you poke around one of these old hearths, you should be able to find a flake or two of charcoal, all that remains of this once flourishing industry (see pages 11 and 13).

When you reach the base of Pole Steeple, you will see that the trail blazes continue up through a zone in the rock face that contains numerous closely spaced, nearly vertical fractures (Figure 8-3A). This is a *fault zone.* At this point, the rock succumbed to tremendous pressure and split, one side moving relative to the other. This happened perhaps as much as 300 million years ago.

As you climb along this fault zone, note the many smooth and polished fault surfaces, called *slickensides,* some of which contain striations, or *slickenlines,* that formed when the rocks slid against each other and show the direction of fault movement (Figure 8-3B). Rub your hand across one of these slickensided surfaces parallel with the lines; one direction is smooth, the other rough. It was commonly believed that the direction of fault movement was in the smooth direction. However, recent studies suggest that the smooth-versus-rough feel is not reliable for determining the direction of movement.

Upon reaching the rock ledges of Pole Steeple (Figure 8-4), you are greeted by a splendid panorama of broad, rounded summits and gentle, forested slopes (Figure 8-5). Laurel Forge Pond, its beach and boating areas clearly visible, fills the valley of Mountain Creek below. South Mountain is the highest continuous ridge on the skyline to the north and northwest.

After you have viewed the distant landscape, take this opportunity to examine the rocks you are standing on more closely. Some general observations include the following:

(1) The color of the rocks is white or light gray; some areas are covered with a rusty staining.

(2) These rocks are extremely hard and cannot be scratched with a pocket knife; however, the rocks will scratch the knife blade.

(3) The rocks often have a vitreous or glassy appearance.

(4) The layers, or bedding surfaces, slope into the rock face.

(5) These layers have a blocky fracture pattern; large blocks are roughly rhombohedral in shape.

(6) There is a superabundance of the trace fossil *Skolithos,* visible in cross section as long, straight, sand-filled tubes (8+ inches) and from the top, on the bedding surfaces, as small, round or oval-shaped rings, 0.16 to 0.20 inch in diameter.

At this point an intriguing question can be raised. Are the rocks here the same as or different from the rocks exposed along the ridge at Kings Gap (Chapter 4)? The geologic map of the Dickinson quadrangle shows that the rocks at Pole Steeple are quartzites of the Montalto Member of the Harpers Formation. The quartzites along Ridge Trail are mapped as the Antietam Formation (Chapter 4). Geologists mapping in the South Mountain area have pointed out the similarities of these two units and the difficulty in distinguishing between them. What do you think?

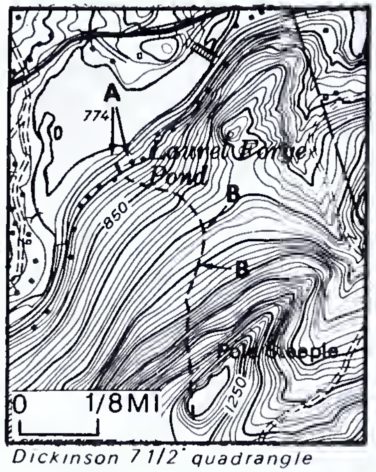
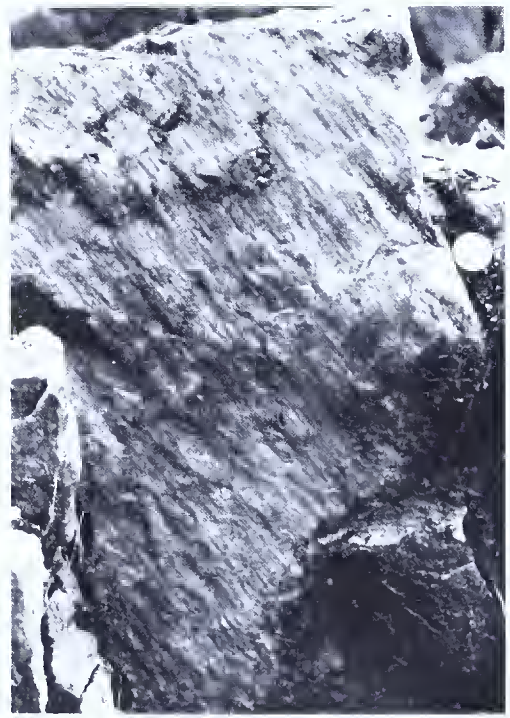



Figure 8–1. Topography surrounding Pole Steeple south of Laurel Forge Pond. The map shows the locations of the parking areas (A) and two of the charcoal hearths (B) along the trail to the top.

Figure 8–2. Remnant of a charcoal hearth along the trail to Pole Steeple.

A

Figure 8–3. A. The blazed trail to the top of Pole Steeple leads through a fault zone that has displaced portions of this massive exposure. B. Slickenlines on the smooth, polished surface of the fault plane.



B

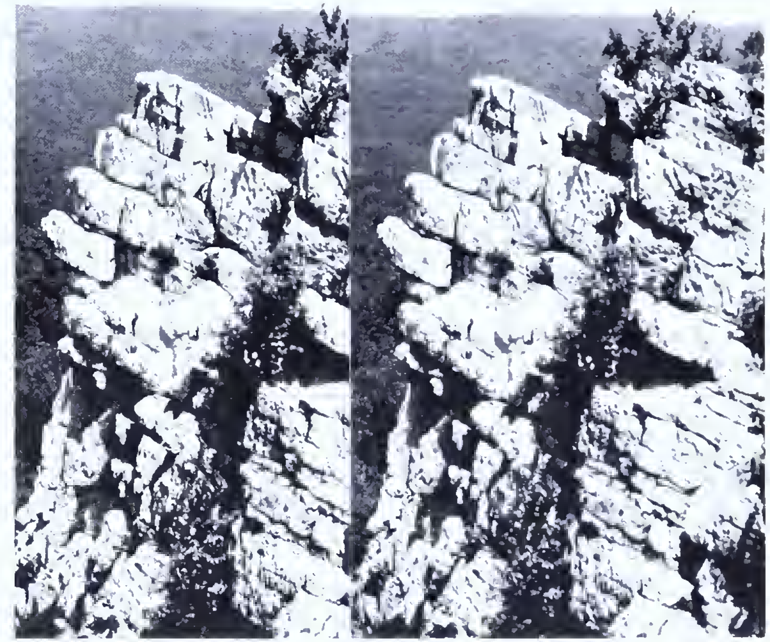


Figure 8–4. Stereoscopic-pair of the northeast-dipping quartzite beds exposed at the top of Pole Steeple. (To observe these photographs in stereo, focus the left eye on the left photograph, the right eye on the right photograph, and bring the images together. A piece of cardboard held vertically along the line between the two pictures will aid the beginner.)


Figure 8–5. Panoramic view from atop Pole Steeple.

# 9. HAMMONDS ROCKS AND THE WEVERTON CONGLOMERATE ROCK RIBS

LOCATION: Hammonds Rocks, a prominent topographic feature in the South Mountain area, lies on the south side of Ridge Road, a well-maintained dirt road along the crest of South Mountain (Figure 9-1; 9a on centerfold map). It can be recognized by a large turnoff. As the crow flies, this area is approximately 2 miles southeast of the Kings Gap Environmental Education Center and 3.8 miles northeast of Pine Grove Furnace in Dickinson Township, Cumberland County.

*Caution:* Broken glass is frequently scattered about the exposure; this presents a hazard, especially to young children. Second, the rock surfaces are moderately smooth and potentially slippery, having been polished by many thousands of shoes over the years. In addition, the natural roughness is further reduced by the gray paint that has been used to cover graffiti. Third, although the ladder is firmly attached to the rock, good judgment and care in climbing it and climbing over the rocks themselves is recommended.

VIEW: From atop the highest point on Hammonds Rocks, it is possible to see parts of five physiographic regions—Piedmont, Mesozoic Lowlands, South Mountain, Great Valley, and Valley and Ridge (refer to Chapter 2). Looking across the Cumberland Valley to the north, Sterretts Gap, the most noticeable notch in Blue Mountain, is visible. To the south and east, one can see the Mesozoic Lowlands and beyond to the low hills of the Piedmont in the York Valley. Even on those days when distant visibility is poor, Pole Steeple on Piney Mountain to the southwest should be recognizable.

THE GEOLOGY: A bold, irregular wall of rock, rising 13 to 20 feet above ground level, greets the visitor at the pulloff in front of Hammonds Rocks. This natural exposure presents an excellent opportunity to look at the conglomeratic member of the Precambrian-age Weverton Formation, among the oldest sedimentary rocks in the state (refer to the stratigraphic column, inside back cover).

In addition, riblike exposures of the conglomerate surround Hammonds Rocks at several places in the woods. About 0.3 mile to the north, an extensive, elongated rib of the Weverton, dubbed the "Chinese Wall," is especially prominent and well worth the short hike (crosshatched area on Figure 9-1; Figure 9-2; 9b on centerfold map).

At Hammonds Rocks, the most prominent rock type is conglomerate. Where are the finer grained beds? Being less resistant to weathering, any that were present have been eroded and covered with debris, leaving the hard, resistant ledges of conglomerates protruding above the surface.

WHAT ARE CONGLOMERATES? A conglomerate is a coarse-grained sedimentary rock containing rock or mineral fragments larger than 0.1 inch in diameter (generally pebble sized) set in a matrix of finer grained material such as sand, silt, or clay. The coarse grains and pebbles of a conglomerate are often worn and well rounded; their surfaces are smooth and polished. Concrete is a man-made equivalent of nature's conglomerate.

As with other rock types, conglomerates have much to tell us about geologic history. The composition, shape, and size of the coarse-grained fragments indicate something about the source of the rock material, how far it traveled after it was eroded, and by what methods it was moved into the depositional basin. The types of primary sedimentary structures present, those features that formed when the sediments accumulated, are directly related to the processes responsible for the deposition of the sediment—like telltale fingerprints, they help to identify the agents of deposition.

HAMMONDS ROCKS CONGLOMERATES: The matrix of the Weverton conglomerate consists mostly of small quartz grains and flakes of sericite (a mica mineral). The coarse fraction consists mostly of abundant, pink, well-rounded quartz and quartzite pebbles (Figure 9-3). In addition, angular purple metarhyolite grains and greenish platy metamorphic rock fragments are among a variety of granules and pebbles present.

The composition of the coarser fragments points to the underlying metarhyolites and associated rocks as the source of these fragments. In late Precambrian time, these rocks must have been exposed at the surface to weathering and erosion. The quartz pebbles in the conglomerate indicate that quartz veins (perhaps like the one in Chapter 11) and quartzite rocks also must have been eroded. The places from which these were eroded, however, may have been much farther away; quartz is very resistant to weathering and the grains we see in the conglomerate probably traveled quite a long distance to have become as well rounded as they are.

Sedimentary structures identified in these outcrops, including bedding, cross-strata, small channels, and ripple marks, are used by *sedimentologists,* geologists who study sediments and the processes that move sediments, to interpret the depositional setting for these rocks (Figures 9-4 and 9-5). It has been proposed that a large river or tidal-channel system was responsible for depositing this rock material.

No fossils have been found in the Weverton Formation. Fossils would not only help in the interpretation of the depositional environment, but would also aid in refining our estimate of the age of these rocks. All that can be said with certainty is that they are probably between 600 and 900 million years old.


Figure 9–1. Location of Hammonds Rocks and surrounding areas of rock exposures plotted on portions of the Dickinson and Mount Holly Springs 7½-minute topographic maps.

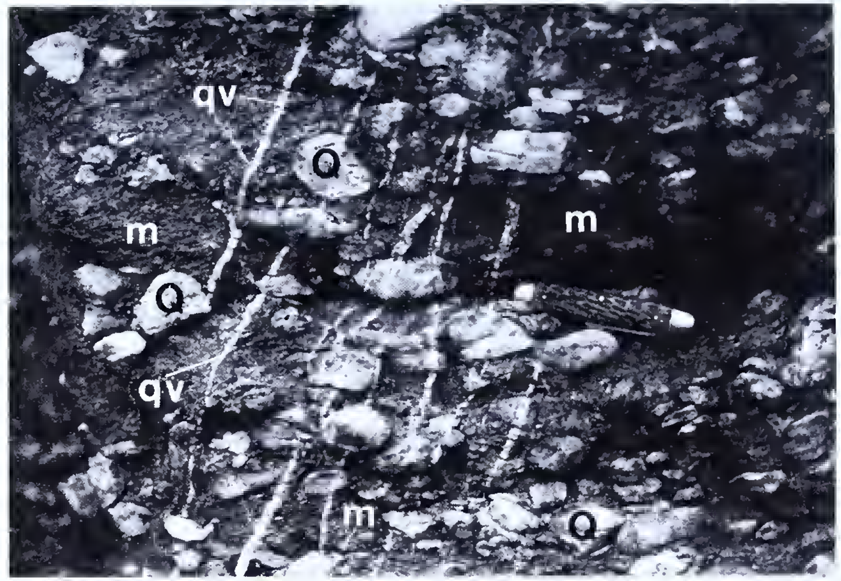



Figure 9–3. Pink, rounded quartzite pebbles (Q) stand out from the finer grained matrix (m), composed of mostly quartz and metamorphic rock fragments, in conglomerate of the Weverton Formation. Thin quartz veins (qv) cut through both pebbles and matrix.

Figure 9–4. Horizontal bedding, cross-strata, and scoured surfaces are among the primary sedimentary structures geologists use to identify the depositional environments of sedimentary rocks.

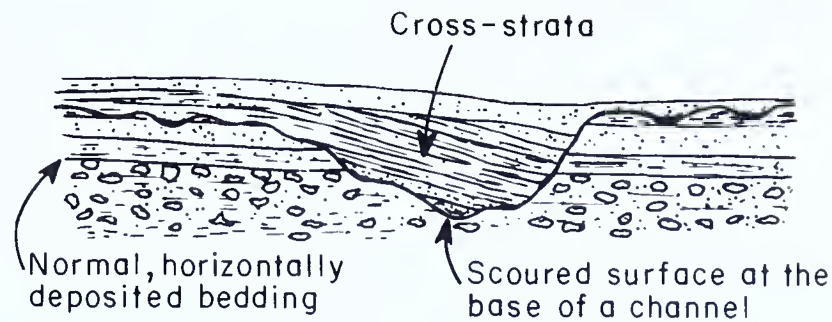



Figure 9–2. A continuous rib of Weverton Formation, nicknamed the "Chinese Wall," is exposed in the woods a short distance north of Hammonds Rocks.


Figure 9–5. The sharp contact between the coarser grained unit (bottom) and the finer grained unit (top) is referred to as a bedding surface. The curved surfaces are ripples, features that can be found today in sediment beneath moving water.

# 10. METARHYOLITE—IGNEOUS ROCKS METAMORPHOSED

LOCATION: One of the most accessible places to look at the metarhyolite is in the roadcut on both sides of Hunter Run Road near the Laurel Forge Pond dam breast at the east end of Pine Grove Furnace State Park (10 on centerfold map).

*Caution:* This road carries moderate traffic, sometimes traveling at higher-than-posted speeds. Remain on the shoulders or banks.

The rocks exposed here belong to the Catoctin Formation, a sequence of metamorphosed igneous rocks named for exposures in Catoctin Mountain of northern Virginia and Maryland. These metarhyolites are among the oldest Precambrian rocks in the area.

ABOUT IGNEOUS ROCKS: Igneous rocks have solidified from *magma,* molten material which is generated at considerable depth within the earth. When magma rises through the crust, it may either cool and crystallize before it reaches the surface, producing *intrusive* igneous bodies, or it may erupt as lava on land or in the sea, creating *extrusive* igneous rocks (Figure 10-1). In general, intrusive rocks take longer to cool than extrusive rocks, allowing the mineral grains to grow larger.

Other variations in igneous rocks are caused by differences in magma compositions which produce dissimilar minerals. For example, volcanic rocks from Mount St. Helens in the Cascade Range have a chemical composition close to the average composition of the continental crust, whereas the Hawaiian volcanoes produce rock characteristic of the thinner oceanic crust. Thus, both grain size and mineral composition are used to determine the origin of igneous rock.

In most igneous rocks, all the grains are about the same size. However, some igneous rocks contain large mineral grains or crystals scattered through a mixture of much finer grained material. A rock with this special texture is called a *porphyry,* and the larger mineral crystals are called *phenocrysts*. The finer grains that make up the rest of the rock are called *groundmass*. A porphyritic texture reflects a two-stage cooling history of the rocks. Initially, in the magma chamber deep within the crust, mineral grains slowly begin to crystallize as the molten material in the chamber cools. This slow growth is interrupted if the magma is pushed near or out onto the earth's surface. There, cooling proceeds much more rapidly and the crystals that form are smaller. The resulting igneous rock contains both large and small mineral grains.

Using this as a brief background to igneous rocks, we can look at the outcrop and try to determine something about the origin and history of these rocks.

OBSERVATIONS AT THE OUTCROP: This roadcut features layers of hard, dense rock that tends to break along uneven weathered surfaces (Figure 10-2). The overall color of the rock varies considerably from light gray to pale red to grayish purple.

A closer look at the rock reveals small white to pinkish-gray, rectangular phenocrysts of feldspar, most between 0.1 and 0.4 inch in length, and even smaller, rounded, pinkish to dark-red phenocrysts of quartz, usually less than 0.1 inch, that appear to float in a very fine grained groundmass (Figure 10-3). An igneous rock that has quartz and feldspar phenocrysts in a fine-grained groundmass is classified as a *rhyolite*.

In addition, tiny, highly reflective, reddish, almost blackish hematite grains coat some rock surfaces. Still other rock fragments contain small veins or blotches of a reddish, sometimes fibrous coating of the epidote-group mineral piemontite (a silicate of calcium, aluminum, manganese, and iron).

INTERPRETING THE OBSERVATIONS: The variation in rock color is primarily due to the presence, amount, and degree of weathering of the iron oxide minerals—magnetite, hematite, and ilmenite. When exposed to the air, these minerals interact with oxygen and water, and they oxidize or, simply put, they rust.

Rhyolites are extrusive igneous rocks that exhibit flow textures and are associated with continental volcanic eruptions. Each rock layer we see may represent an individual extrusive lava flow; however, no structures are evident that would give an indication of the tops or bottoms of the rhyolite flows.

Some of the metarhyolites in South Mountain display porphyritic textures, and others do not. This suggests that magma was intermittently extruded from volcanoes, at times producing lava that was all liquid, at other times pausing, permitting crystallization of some feldspar and quartz in the magma chamber before it was brought to the surface.

WHAT DOES THIS ALL MEAN? Metarhyolites in the South Mountain area vary considerably in texture, color, and structure; the metarhyolite exposed at this outcrop represents just one variety. Geologists mapping throughout the Blue Ridge and looking at all varieties of metarhyolites and associated igneous rock types (metabasalts) have interpreted the metarhyolites as volcanic lavas (Figure 10-4). The period of volcanic activity that produced these rocks has been related to a major continental breakup more than 600 million years ago in Precambrian time that was associated with the formation of a major ocean basin.

After these volcanic igneous rocks (rhyolites) formed, another geologic event affected them. The rocks of this region were buried and subjected to higher temperatures and pressures than exist at the earth's surface. The elevated temperatures and pressures caused new minerals to form and caused some mineral grains to change their position within the rocks. This geological process, called *metamorphism,* brought about enough changes to these igneous rocks that the rhyolites are properly referred to as "metarhyolites."

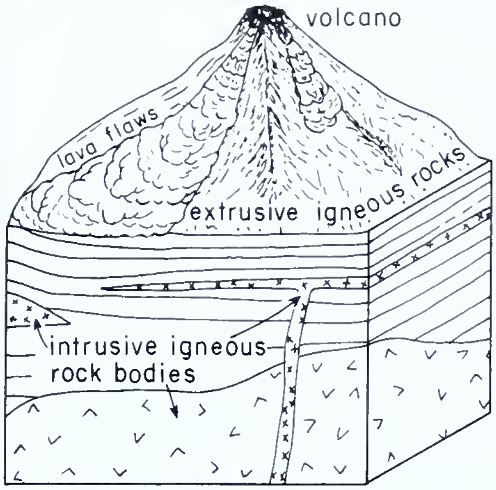
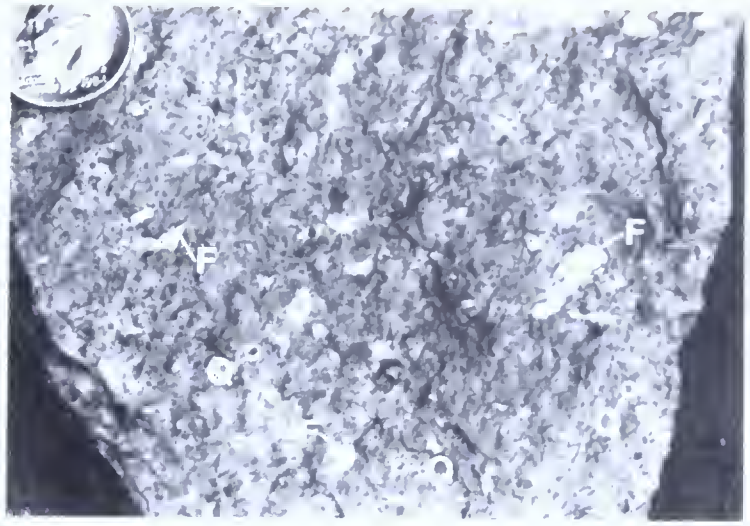



Figure 10–1. Sketch showing examples of both intrusive and extrusive igneous rock bodies.




A

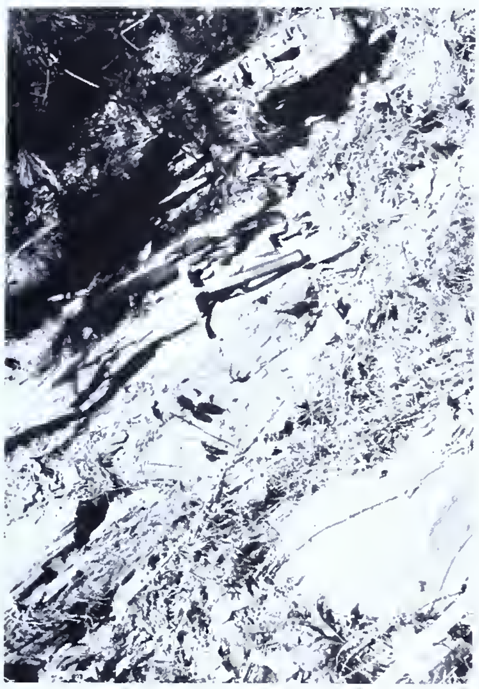
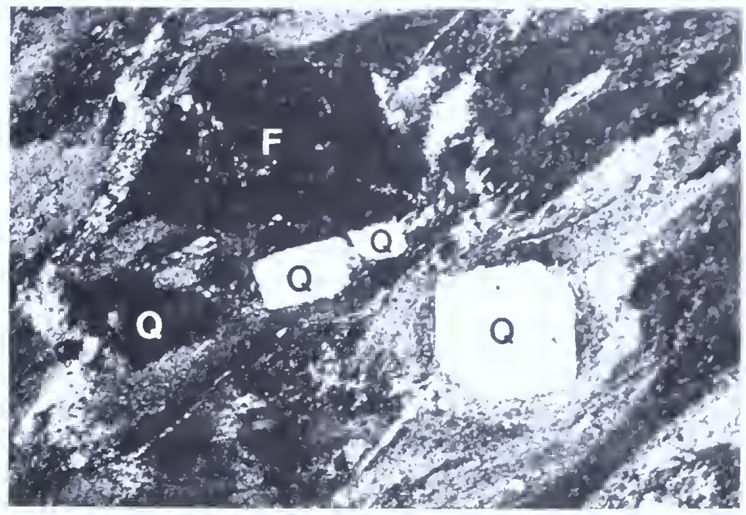


Figure 10–2. Layers of metarhyolite exposed in the roadcut near the dam breast of Laurel Forge Pond at the east end of Pine Grove Furnace State Park.




B

Figure 10–3. A. A sample of the pinkish metarhyolite porphyry. The lighter gray, angular crystals are feldspar phenocrysts (F) and the smaller, dark, rounded grains are quartz phenocrysts (Q). Individual mineral grains cannot be seen in the finer grained groundmass. B. A photomicrograph of the metarhyolite porphyry. The edges of the quartz grains (Q) are sharp and well defined, whereas the larger, irregular feldspar grain (F) has been severely weathered. No individual grains are visible in the groundmass. (Note the hexagonal crystal habit of the largest quartz grain.)

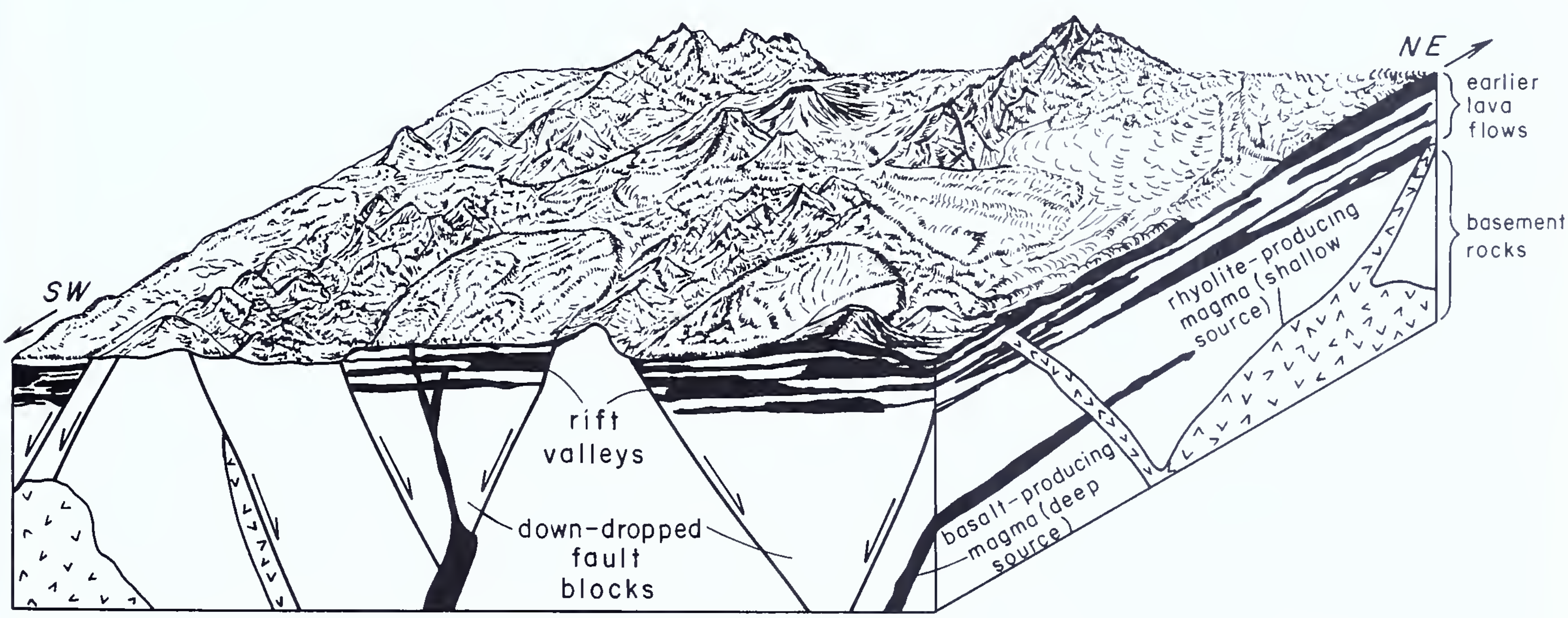



Figure 10–4. Sketch of late Precambrian paleogeography at the time the Catoctin volcanics were being formed. Interbedded rhyolite and basalt lava flows filled deeply rifted valleys in the older Precambrian basement rocks. About 9,000 feet of Catoctin Formation was encountered in drilling in the South Mountain area.

# 11. TOMS RUN QUARTZ VEIN

LOCATION: This hilltop exposure of quartz, 1,085 feet above sea level, occurs in Michaux State Forest, Cooke Township, about 0.5 mile north of the ironmaster's mansion house in Pine Grove Furnace State Park (11 on centerfold map). A trail off Old Shippensburg Road provides access to the quartz vein 0.25 mile northeast of the paved road (Figure 11-1A).

WHAT TO LOOK FOR: A massive outcrop of white (milky) quartz rises abruptly 13 feet or more on the northwest side of this unnamed hill (Figure 11-2). The slightly steeper, southeast side of the hill below the quartz deposit is covered with quartz boulders of various sizes that have broken off the main mass and moved downslope. Nearby, about 600 feet to the southwest, the soft metavolcanic schist that is the host rock for the quartz is exposed.

THE GEOLOGY: This 15- to 20-foot-thick quartz vein fills a fracture or crack in the older metamorphic rock. Presently, the quartz stands above ground level, but when it formed, it must have been surrounded by the metavolcanic schist, rock that since has been removed by erosion.

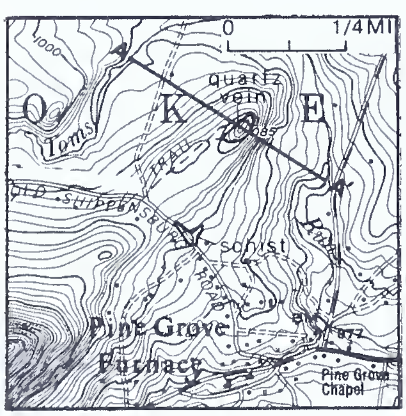
When the quartz crystallized is unknown; however, it could have been when the rocks of this area underwent metamorphism. Rocks are metamorphosed when they are exposed to much higher temperatures or pressures than exist at the earth's surface. Under these conditions, hot, mineral-rich waters move through the interconnected network of cracks in the rocks. These hydrothermal solutions are often enriched in silica and, upon cooling, deposit quartz in the open fractures and cavities.

SOMETHING ABOUT THE MINERAL QUARTZ: Quartz is one of the most common materials in the earth's crust. An essential part of many igneous, sedimentary, and metamorphic rocks, quartz is a combination of the elements silicon and oxygen (chemical formula: $SiO_2$). It occurs in many forms, textures, and colors. Chert, flint, jasper, agate, chalcedony, and amethyst are among the many varieties of quartz.

Most commonly, quartz occurs as small, rounded or irregular grains in rocks, including those found all around the Kings Gap area. Less commonly, it forms massive, relatively pure veins of milky quartz. Although milky quartz veins occur in many exposures throughout South Mountain, they usually are less than 1 inch thick (see Figure 9-3).

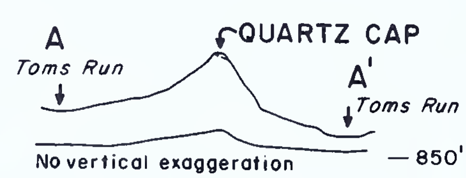
ABOUT THE LANDSCAPE: Quartz is hard and not easily broken down into smaller particles by the physical and chemical processes that cause weathering and erosion in this temperate, humid climate. A topographic profile of this ridge graphically demonstrates the resistance to weathering exhibited by this quartz vein (Figure 11-1B). Using a vertical exaggeration of 4, the difference between the quartz and the underlying metavolcanic rocks is better illustrated.

The same concept of differential weathering and the resistance of quartz may be seen at a smaller scale in the stereographic pair of photographs shown in Figure 11-3. The white quartz stands high above the softer, less resistant metamorphic rock.




A

Figure 11–1. A. The trail and quartz vein plotted on a portion of the Dickinson 7½-minute quadrangle. B. Topographic profile A–A′. Upper profile shows a vertical exaggeration of 4.




B

Figure 11–2. Northwest view of Toms Run quartz vein. The face height is approximately 16 feet. Hammer shows scale.

Figure 11–3. Stereoscopic pair of photographs demonstrating the effects of differential weathering. The quartz vein stands out in high relief from the surrounding metamorphic rock. Instructions for viewing a three-dimensional image are given in Figure 8–4.

# 12. SANDSTONE BORROW PIT



LOCATION: Approximately 0.7 mile south-southwest of the ironmaster's mansion house in Pine Grove Furnace State Park, a sandstone borrow pit has been dug into the hillside (12 on centerfold map). A short, inclined dirt road provides access into the pit; however, parking in the lot on the opposite side of the paved road is encouraged because equipment may be operating.

*Caution:* Climbing slopes and highwalls is hazardous; rockfalls are common.

LOOKING AT AN ECONOMIC MINERAL RESOURCE: The pit that has been developed here (Figure 12-1) provides rock that is used mainly by lumber companies to top-dress haul roads in Michaux State Forest. In the past, rock from this pit has also been purchased and used by several local townships for fill and road base.

Even though it may not appear very glamorous, a mineral resource such as this is a valuable asset. Although not of the best quality as aggregate for road surfaces, concrete, and other construction uses, this rock can be excavated relatively easily and requires no crushing before it is used, making it inexpensive. If this material were difficult to excavate, production costs would increase, ultimately resulting in higher product prices. Thus, everyone benefits from this particular mineral-resource operation: the Commonwealth by contributing to the management of the lumber production from which it derives revenues, the companies by keeping their costs lower, and the consumer by paying less for the final product.

WHAT THESE ROCKS CAN TELL US ABOUT THEIR HISTORY: Pick up several pieces of the rock and try crushing them in your hand. The rock that crumbles easily, described as "friable," has undergone more intense weathering than the fresher, harder pieces.

Carefully examine the fragments of rock you are holding; use a hand lens (magnifying glass) if you have one. Close inspection will reveal many tiny, rounded mineral grains. These grains are mostly quartz, a very common rock-forming mineral.

How are these little quartz grains held together to form a rock? By more quartz, sometimes called "silica cement." Just as bricks are held together by mortar in a brick wall, the quartz that is between the grains binds the grains together (Figure 12-2). Thus, the quartz grains and the quartz cement are the main components of this rock, called a quartz sandstone, one type of sedimentary rock (Figure 12-3).

It would not require too much imagination to take a handful of New Jersey beach sand and bind the grains together with quartz cement to make a sandstone such as this. Similarly, it would not require that much more thought to transport yourself back to the time when this sandstone was just loose grains of sand. Where might you be? Probably you would be standing on a beach or swimming in the shallow waters of an ancient ocean, watching the waves rolling sand grain against sand grain and, in the process, slowly smoothing, rounding, and polishing them. A beach or offshore sandbar is probably the ancient depositional setting for the sandstone in this pit, and it existed about 570 million years ago.

◄ Figure 12–1. Gullied face of the sandstone borrow pit. Highly weathered blocks of sandstone cover freshly exposed sandstone in outcrop.

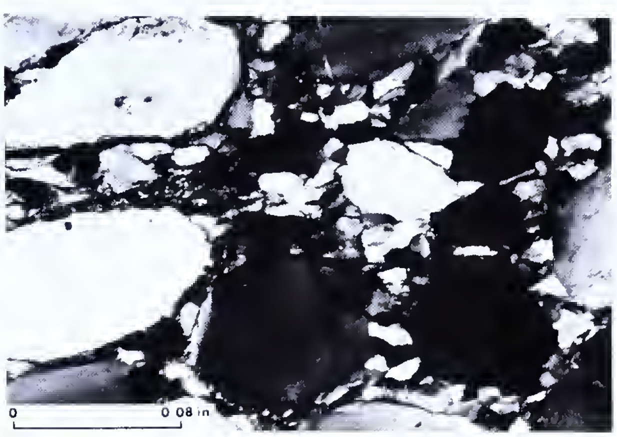



Figure 12–2. A photomicrograph of the quartz sandstone. Compare the sharp, well-rounded edges of the larger quartz grains with those in Figure 4–4 (page 8), another quartz-rich rock, which may have originally looked similar to this before ◄ being metamorphosed.

Figure 12–3. A block of the coarse-grained sandstone. Horizontal lines defined by well-rounded sand grains are bedding, primary depositional features. Dime shows scale. ►

# 13. CLAY MINING AT THE TOLAND PITS

LOCATION: This extensively mined area, visible from Hunters Run Road as a series of spoil piles on the hillside above the town of Toland, is midway between Mount Holly Springs and Pine Grove Furnace State Park (Figure 13-1; 13 on centerfold map).

*Please note:* The Toland mine is a working quarry, owned by Hempt Brothers of Camp Hill, and is *not* open to the public. For your own protection, respect this private property and obey the "No Trespassing" signs.

GEOLOGIC SETTING: Both limonite (brown iron ore) and white clay, used in the manufacture of paper, brick, and white cement, occur together. The clay was first exposed while iron was being mined in the 1880's, but it was not until the early 1900's that its value was fully realized.

The most extensive and valuable clay deposits were found in Mountain Creek valley on the southern flank of Mount Holly in the vicinity of Hunters Run and Toland. The Chestnut Hill, Dunbar, Crane, and Lehman iron ore mines had been developed here around 1885 (see Figure 6-2). The ore bodies were exceedingly irregular and mixed with clay, a nuisance because of the large amount of water required to remove it. The richer concentrations of limonite tended to occur to the north, closer to the mountain.

The sharp northern boundary of the iron and clay deposit is a fault. As a result, the deposit is in direct contact with the Montalto Member of the Harpers Formation (Figure 13-2). This fault played a role in the formation of these minerals, but its exact role is unknown. The southern boundary grades from white clay through yellow, pink, red, and brown silty clay, and eventually into grayish-green to light-gray phyllite, a metamorphosed rock unit within the Tomstown Formation. Clay is often formed by chemical weathering, the result of many years of exposure of the rock to the water, air, and organic matter found at the earth's surface. It is possible that this lateral gradation reflects various degrees of weathering: the white clay, the final weathering product; the variegated clay, an intermediate stage; and the phyllite, the parent material.

HISTORY OF MINING ACTIVITIES: Between 1890 and 1910, at least five companies mined white clay deposits in the Mount Holly Springs area (Figure 13-3). The Philadelphia Clay Company, located at the old Crane iron ore banks, presently the site of the Toland mine, owned the most extensive clay deposit. At that time, its mine and mill were the largest and best equipped in the region.

Mining involved tunnels driven into the mountainside and "headings" that branched in two directions at right angles under the clay beds. At an appropriate place, a large room was excavated along the heading and, when the supporting props and pillars were removed, the clay crumbled or flowed down into the room (Figure 13-4). The crude clay was then loaded into carts (Figure 13-5) hauled out of the tunnels by mules or a locomotive to the mill located near the mine mouth (Figure 13-6).

The raw material consisted of clay mixed with silt, sand, and larger rock fragments. A variety of patented processes were used to separate the clay, but basically all such beneficiation involved mixing the raw material with huge volumes of water. The coarse material settled out and the clay became suspended in the water, producing a milky liquid called *slip*. After screening to remove even the finest impurities, the purified slip was collected and distributed to settling tanks. After a day or two, the thick slip was drawn from the bottom of the tanks and pumped through a series of presses to remove water and to mold the clay into cakes, which were then taken to drying ovens. The clay was sold either in bulk, in small pieces, or by the bag (pulverized).

The principal use for the white clay from this area was originally in the manufacture of paper, especially that requiring a smooth, absorbent surface for fine printing. These South Mountain clays, when mixed with more-plastic clay for body, produced excellent, light-colored building brick that was both hard and impervious. White bricks stamped "Mt. Holly" were used for the interior bearing walls of the Kings Gap mansion, and sidewalks made with these bricks are still in use in Cumberland County. This clay was also made into white enameled tiles, some of it found its way into the potter's mixture for chinaware, and it also served as an additive for paints.

By 1934, only two companies were mining clay in this area — the Philadelphia Clay Company and the Medusa Portland Cement Company, the latter mining the old York Clay Company's prospect (Figure 13-3). In 1978, the Medusa Company was operating the Philadelphia Clay Company's pit, but in the late 1970's, Medusa sold its interest in Mountain Creek valley to Hempt Brothers, thus opening up the third, and present, chapter in the history of this deposit.

Today, the clay dumps, colluvial hillside material, and some bedrock at the Toland mine are being processed by Hempt Brothers for coarse and fine aggregate. Coarse aggregate, or gravel, is used in street and highway projects, in making concrete, and in constructing septic drain fields. In winter, this aggregate is mixed with calcium chloride and sodium chloride and spread on roads as an antiskid material. Fine aggregate, sold as sand, has a variety of commercial and domestic uses. Sand is added to asphalt as a filler, it is a major component in mortar, and it is used in the construction of sand-mound septic systems.

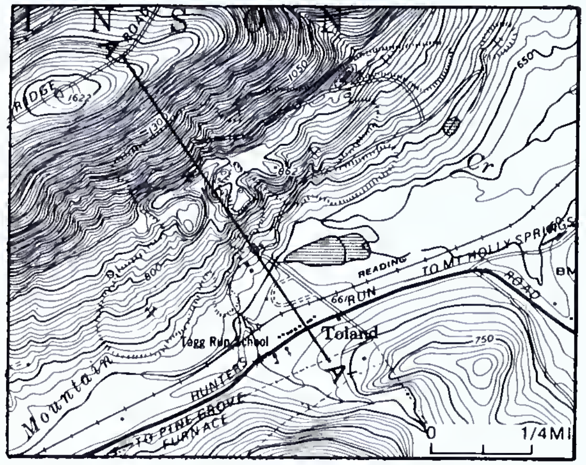



Figure 13–1. The Toland mine area plotted on a portion of the Mount Holly Springs 7½-minute topographic map. See Figure 13–2 for cross section A–A'.

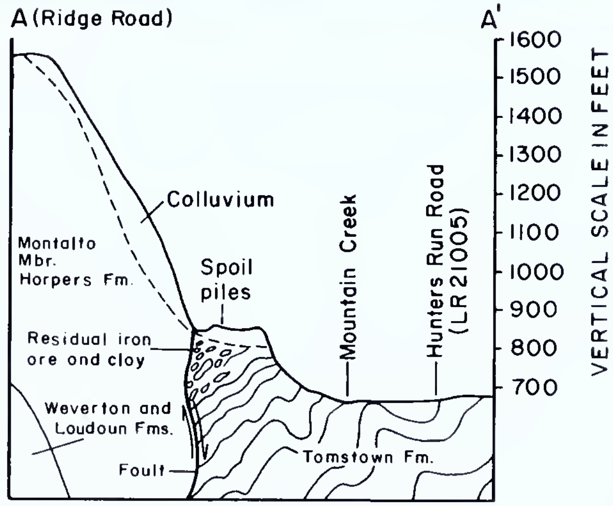



Figure 13–2. Topographic and geologic cross section from Ridge Road (A) on the northwest to Hunters Run Road at Toland (A') on the southeast (vertical exaggeration x4).

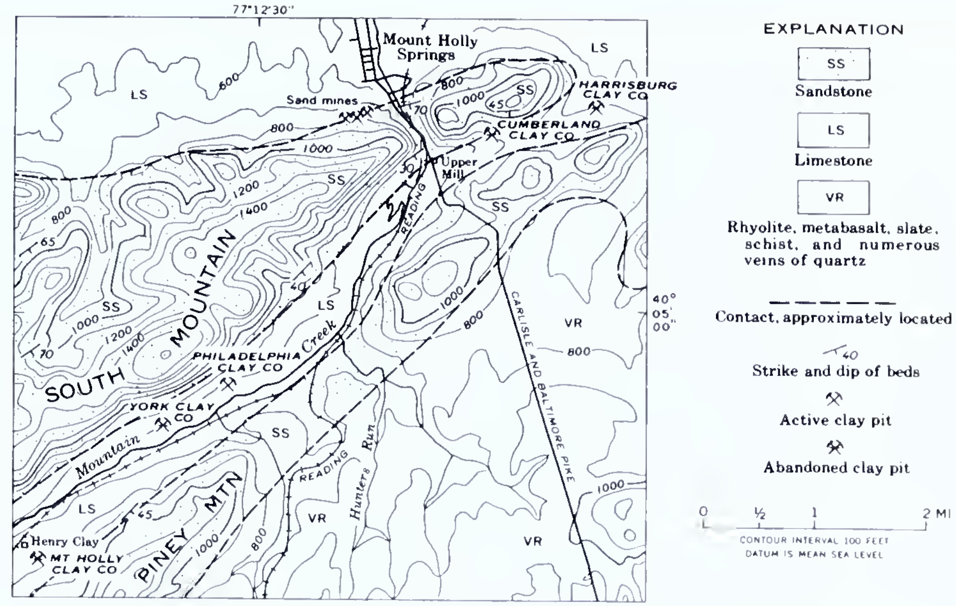



Figure 13–3. A 1907 geologic map indicating the locations of active and abandoned clay pits in the Mount Holly Springs area (after Hosterman, 1969, p. B67, redrawn after Stose, 1907, p. 327).

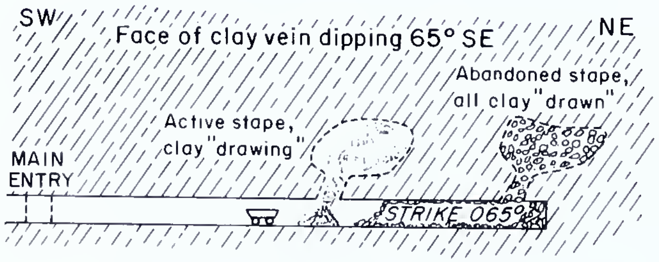



Figure 13–4. Sketch of a "heading" off the main entry of the Philadelphia Clay Company's mine, circa 1940. Once the recoverable clay is "drawn," new stopes are cut along the heading (after Leighton, 1941, p. 117).

Figure 13–5. Both underground and open-cut mining methods were used to produce white clay along the sides of Mount Holly. (Photograph by G. H. Ashley, July 21, 1924, Pennsylvania Geological Survey files.)

Figure 13–6. The Philadelphia Clay Company's mill, probably taken shortly after the turn of the century. (Photograph courtesy of the Cumberland County Historical Society.)

# 14. IRON, MANGANESE, AND PHOSPHATE MINERALS

The study of minerals is an interesting aspect of the science of geology. It also provides many people an opportunity to enjoy a fascinating hobby. Both hobbyists and scientists have scoured old pits in search of mineral specimens and a better understanding of the geology of the region. As a result, several interesting minerals and mineral associations have been described from South Mountain. The minerals mentioned below are some of the more common species; this is not a complete listing of all the minerals documented and verified from this area.

As has already been discussed (Chapter 6), iron minerals played a key role in shaping history in and around South Mountain. The bulk of the iron ores in this region consist of *limonite,* a general term for hydrous iron oxides, usually including the mineral *goethite*. When pure, goethite often appears as a shiny, black coating on masses of limonite. Red, fibrous *lepidocrocite,* another iron oxide, has been reported in trace amounts.

Fragments of limonite may be found surrounding many of the old iron ore pits, such as Laurel No. 1 bank (7d on centerfold map). These occur in varying sizes and display a great diversity in form. Nodular ore, pipe ore, bombshell ore, brecciated ore, flake or sheet ore, fragmental ore, and yellow ochre are among the descriptive terms applied to limonite by past workers.

These limonite ores vary as much in quality (i.e., percent iron content) as they do in form. Chemical analyses of the South Mountain ores have indicated that they are not particularly rich in iron, yielding between 36 and 54 percent metallic iron. Impurities, especially manganese and phosphorus, created serious problems for the ironmasters, and ore banks so tainted rarely produced more than a few batches of ore before being abandoned.

For the most part, fragments of limonite occur in residual deposits resting upon limestones or sandstones, or along fault zones (Figure 14–1). Clay, sand, chert, and rock fragments make up the bulk of these deposits, which are irregular in outline and variable in depth, some pockets extending hundreds of feet below the surface.

Manganese oxides are closely associated with limonite. Similar in appearance to the iron oxide minerals, they have a black or blue-black color. *Pyrolusite* and *cryptomelane,* two of the most common manganese minerals, are both dark colored and occur in similar forms. These two minerals may be distinguished from each other by their hardness.

Pyrolusite is an opaque, gray-black to black, granular mineral with a dull, earthy luster. It is soft enough to be scratched by the fingernail and usually leaves a sooty black smudge on hands and paper. It occurs as nodules with concentric banding and rough, bulbous surfaces (Figure 14–2).

Cryptomelane, also a gray-black to black mineral, is dense and often occurs in small nodular or grapelike clusters with well-developed coliform or globular texture (Figure 14–3). It is much harder than pyrolusite.

Associated with the manganese and iron ores in some of these residual deposits are white nodules and nodule aggregates within cream-colored or white clays. When broken, the less weathered nodules contain beautiful radiating fibers of *wavellite,* an aluminum phosphate mineral (Figure 14–4). At one locality, Moore's (Moors) Mill (14a on centerfold map), this material proved to be sufficient in purity and quantity to be mined. In 1900, an operation was begun by the American Phosphorus Company. Both an open cut and shafts were dug, and it was reported in 1906 that phosphate ore was encountered "from a depth of 12 to 52 feet." However, problems with groundwater severely limited further production and, in 1907, mining ceased.

The phosphate ore was processed locally in a plant built at Moore's Mill. Following a major fire, the mill moved to York Haven on the Susquehanna River to take advantage of the less expensive, water-generated electricity. At that time, the chief use of the phosphorus was for making matches. Today, much of the phosphate produced in the United States is used for fertilizers and, in smaller quantities, for detergents, animal-feed supplements, and food products.

In addition to the wavellite, several other iron phosphate minerals have been identified from this locality, mostly as microminerals that are best observed under a low-powered microscope. These include *beraunite,* radial clusters of orange-red microcrystals; *cacoxenite,* radial clusters of yellow-orange microcrystals; and *strengite,* grayish-white to greenish radial clusters of microcrystals. One mineral that occurs here, not usually associated with Pennsylvania, is *turquoise,* appearing as small, blue flakes within the clays.

It should be emphasized that the Moore's Mill locality, along with several other iron and manganese ore pits including the Wharton mine and the McCarrick pit on the north slope of South Mountain (14b and 14c, respectively, on centerfold map), are on private property. Permission to visit these sites *must* be secured from the owner before entering the property. For more specific information refer to three references listed on page 31: Geyer and others (1976), Foose (1945), and Smith (1977).

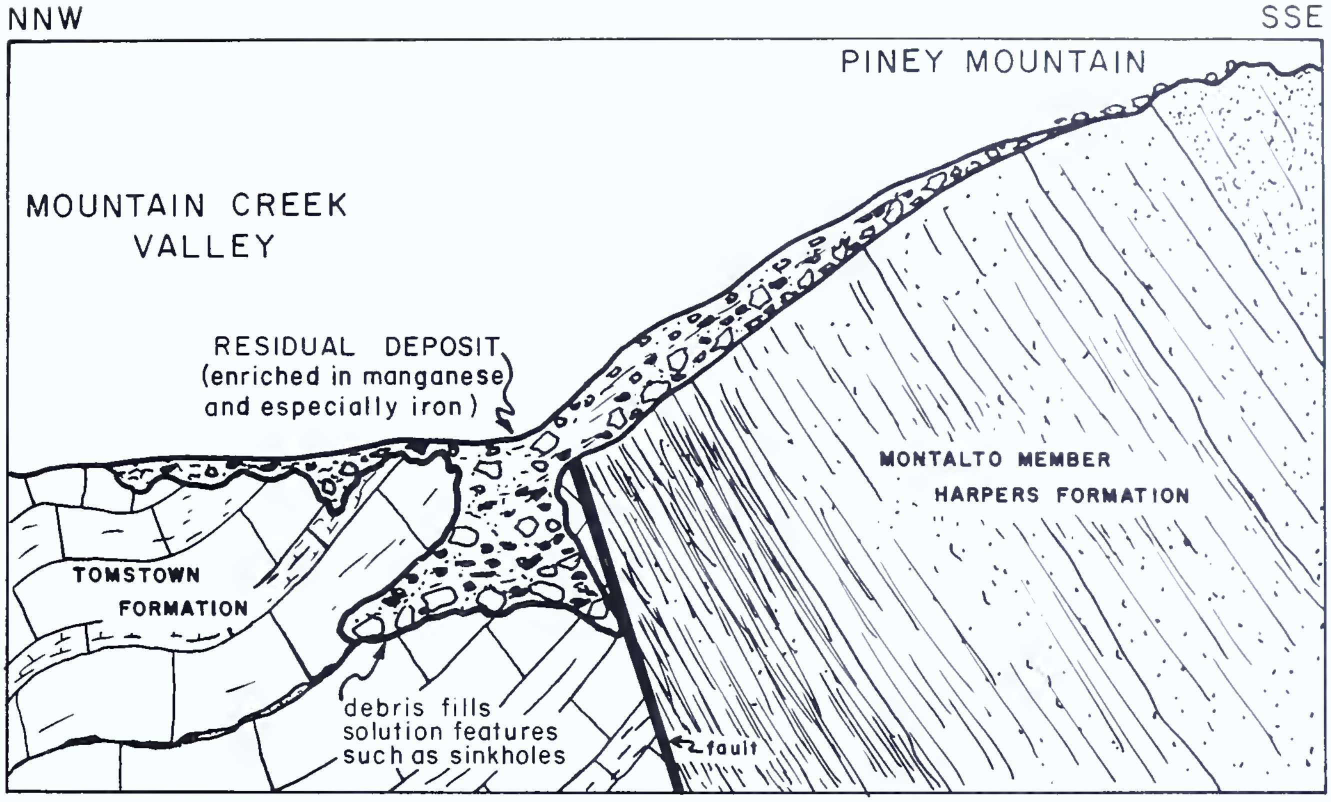



Figure 14–1. A sketch of the geologic setting for a residual iron-manganese deposit in Mountain Creek valley near Pine Grove Furnace State Park. A similar cross section, minus the fault, could be drawn for the Antietam and Tomstown Formations on the north side of South Mountain near Kings Gap.

Figure 14–2. Pyrolusite fragments, collected from pits along the north side of South Mountain, display a variety of sizes and shapes.

Figure 14–3. A cryptomelane nodule from the north slope of South Mountain.

Figure 14–4. Radiating needles of wavellite, a mineral that was mined for its phosphate content at the base of the mountain near Kings Gap in the early 1900's. Needles are about 0.1 inch long.

# 15. THE GEOLOGY OF SOUTH MOUNTAIN

The foundation for this guidebook is geology and each chapter has dealt with how it applies to a particular site or area. This final chapter presents the "big picture" as it is understood today. This overview includes the stratigraphic column (inside back cover) and the geologic map and cross section (Figures 15-1 and 15-2).

The stratigraphic column is a graphic record of the rock units present in a locality and their relation to geologic time. The geologic map shows where these rock units are exposed at the surface of the earth or just beneath the soil. Many rock units exist over greater areas than this map indicates, but beneath other rock units as shown on the cross section. These illustrations represent the combined efforts of a great many geologists, who began accumulating data in the mid-1800's. New information, whether from a recently drilled core hole, a fresh roadcut, or a sophisticated geochemical or geophysical research project, is continuously being added to what is already known. As a result, present interpretations may be confirmed, modified, or radically altered. The rocks do not change, but our understanding of them does.

Within any area, we begin by observing the rock units that are near the surface and their relationship to each other. Two basic fields of geology, *stratigraphy* and *structural geology,* involve the study of these relationships and provide the framework upon which all other data are evaluated.

REGIONAL STRATIGRAPHY: The stratigraphic column shows the names and relative ages of the rock and surficial units included in the South Mountain area.

The Catoctin Formation, mostly volcanic metarhyolites, and the overlying Chilhowee Group, a series of metamorphosed sedimentary rock units, occur extensively throughout the Kings Gap area of South Mountain. The Chilhowee Group includes the Weverton Formation, noted for the resistant ledges of conglomeratic quartzites; the Harpers Formation, represented in this area by the Montalto Member, a series of white quartzite beds containing the trace fossil *Skolithos* in some beds; and the Antietam Formation, also comprising white, vitreous quartzites containing *Skolithos*. The Loudoun Formation, the basal metasedimentary unit, is poorly exposed here.

A series of carbonate-rich units, limestones and dolomites with interbedded mudstones, overlies the Chilhowee Group. Other than a thin sliver of the Tomstown Formation in Mountain Creek valley, these units lie to the north and west of South Mountain in the southeastern half of the Great Valley. The Martinsburg Formation, principally dark-gray shale with some interbeds of sandstone, makes up the rest of the Great Valley. The Hamburg sequence, a series of sandstones and shales, occurs from Carlisle eastward beyond Harrisburg. This sequence, which includes rocks of Martinsburg age and older, has been moved into this part of the Great Valley from the southeast by a series of low-angle thrust faults during Martinsburg time.

Blue Mountain, the first ridge of the Appalachian Mountains beyond the Great Valley, is underlain by the Juniata and Tuscarora Formations, units dominated by dense, quartz-rich sandstones.

Immediately to the south and east of South Mountain, the Mesozoic Lowlands contains the youngest rocks in the area. These Late Triassic- to Early Jurassic-age sedimentary rock units are about 200 million years old. They consist of red conglomerates, sandstones, siltstones, and mudstones in fault contact with the Precambrian and Lower Cambrian rocks of South Mountain.

Finally, unconsolidated accumulations of mud, silt, sand, gravel, and at times, boulders cover portions of this region. The ages of many of these deposits are unknown, and they provide geologists with ample opportunity for speculation about their history.

REGIONAL STRUCTURE: The rocks of South Mountain and the Valley and Ridge province to the west were all involved in a major mountain-building episode approximately 290 million years ago called the Alleghanian orogeny. Folds and faults developed, resulting in the geometry and arrangement of the rock units shown on the geologic map. On this map, the rock units pinch and swell, curve and interfinger, largely as a result of the folding. They are cut and displaced by many large- and small-scale faults. However, a geologic map shows only a two-dimensional picture of what is happening on the earth's surface. The cross-sectional diagram, Figure 15-2, shows what might be seen if we could remove a giant slice from the crust. The diagram shows that the rocks of South Mountain have been folded into an *anticlinorium,* a term used for a large, arched composite structure comprising many smaller folds.

Much of the geologic evidence suggests that the force that deformed the rocks must have come from a southeast direction. Geologists think that this force was generated by two continental plates, the North American plate and the African plate, colliding with each other. At least one major fault zone developed at some depth in the crust. This zone allowed the rocks above the fault to move up and over the rocks below, much as a rug slides over a smooth floor. As these rocks were pushed westward, they met resistance from the rocks ahead of them, and folding and faulting resulted.

The rocks seen in South Mountain today were originally deposited many miles to the east. They, like the rug in the example above, "slid" as an entire mass to their present location, pushed by the same crustal forces responsible for producing the Appalachian Mountains.

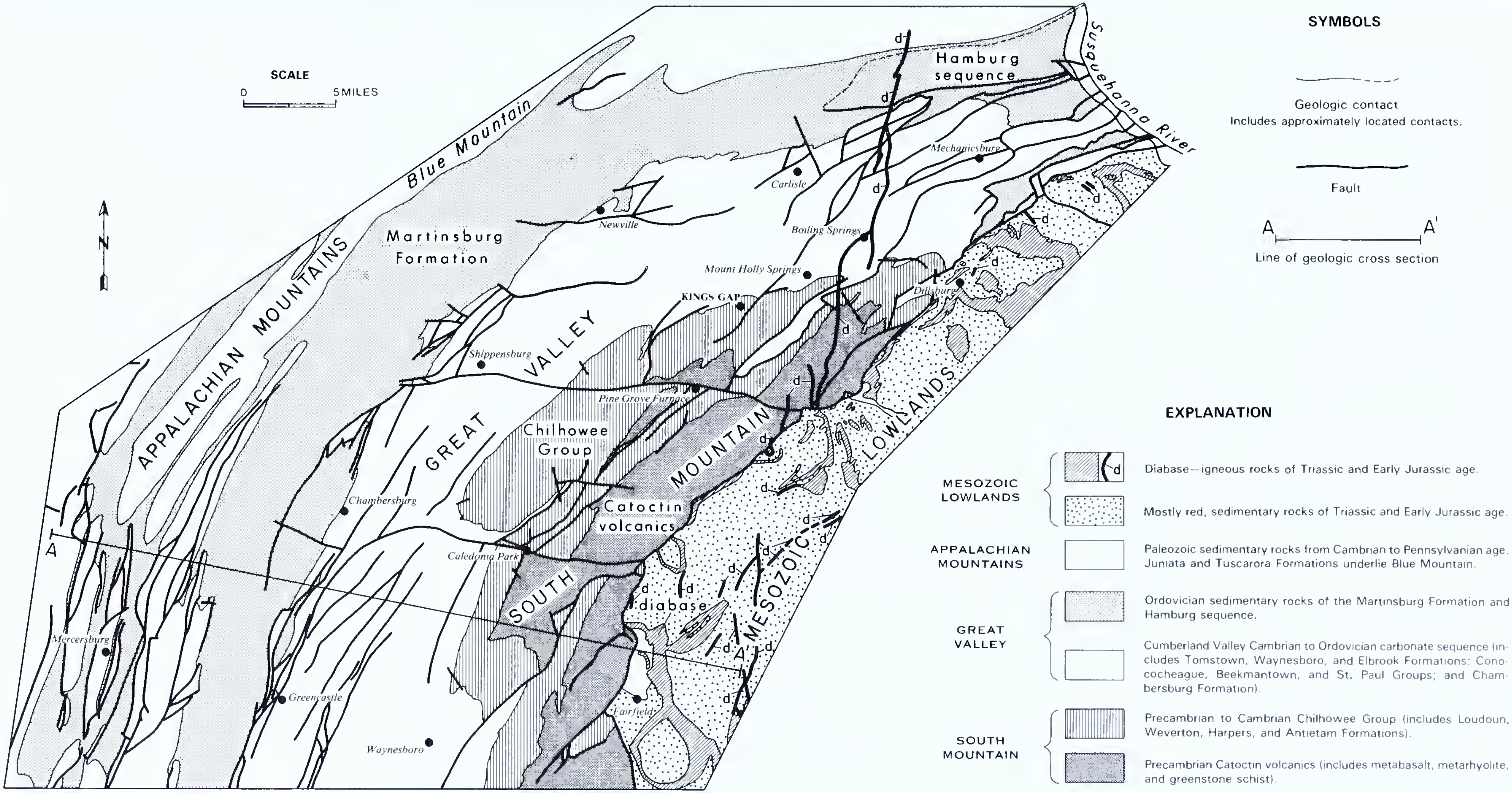



Figure 15–1. Geologic map of the South Mountain area, south-central Pennsylvania (from Berg and others, 1980). See Figure 15–2 for cross section A–A′.

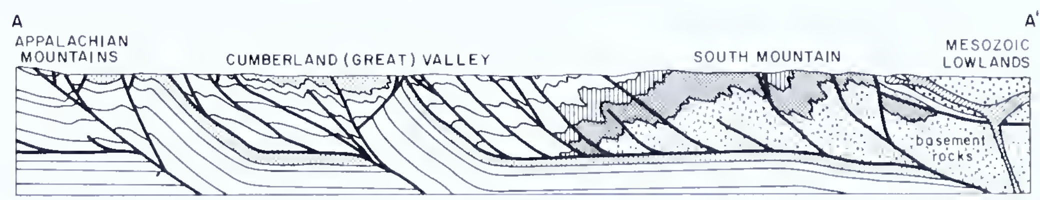



Figure 15–2. Geologic cross section A–A′ showing the South Mountain anticlinorium, the continuation of these structures to the west under the Great Valley, and the downfaulted Mesozoic Lowlands to the east. (After Berg and others, 1980, and R. T. Faill, personal communication, 1985.)

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Cumberland County Historical Society and the Hamilton Library, 21 North Pitt Street, P. O. Box 626, Carlisle, PA 17013.

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Pennsylvania Geological Survey, Executive House, 9th Floor, Second and Chestnut Streets, Harrisburg [P. O. Box 2357, Harrisburg, PA 17120–2357].

Shippensburg University, Geography-Earth Science Department, Shippensburg, PA 17257.

State Museum of Pennsylvania, Third and North Streets, Harrisburg [P. O. Box 1026, Harrisburg, PA 17108–1026].

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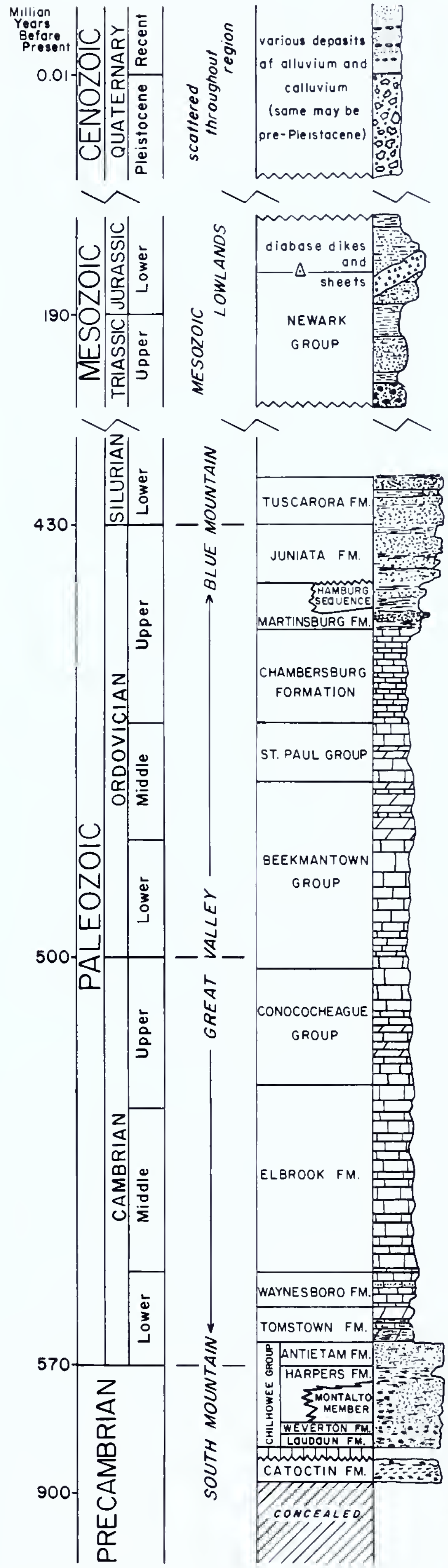
# STRATIGRAPHIC COLUMN FOR THE KINGS GAP AREA




*NOTE: Thicknesses shown here do not represent true thickness.*

A *stratigraphic* or *geologic column* presents the sequence of rock units for a particular locality or region. The units are usually arranged with the oldest at the bottom and the youngest at the top. Thicknesses, descriptions, and certain characteristics such as engineering, hydrologic, and mineral-resource potential may also be given for each rock unit.

The terms used in this column are standard terms used by geologists and are briefly explained below:

The *Precambrian* includes all the rocks formed before the Cambrian Period, which marks the beginning of the Paleozoic Era. The Precambrian is equivalent to about 90 percent of the time from the formation of the earth to the present.

The three eras that follow the Precambrian reflect the biologic character of geologic time over the last 570 million years. Derived from Greek root words, the *Paleozoic, Mesozoic,* and *Cenozoic* can be translated as the eras of ancient (*paleos*), middle (*mesos*), and recent (*kainos*) life (*zoe*). The earliest fossil evidence of most classes of plants, *invertebrates* (animals without backbones), and some *vertebrates* (animals with backbones) is found in rocks deposited during the Paleozoic. The eras of abundant life, the Mesozoic and Cenozoic, are often referred to as the age of reptiles (the age of dinosaurs) and the age of mammals (the age of man), respectively.

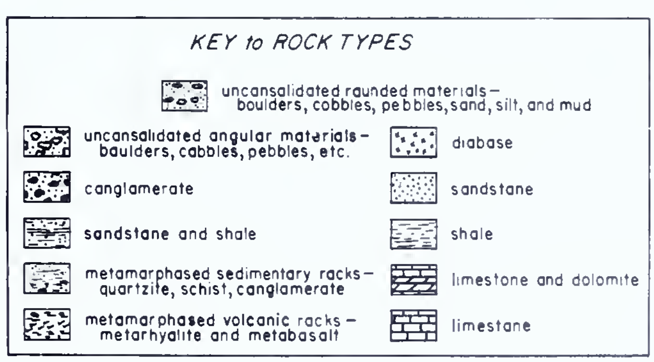
*Cambrian, Ordovician,* and *Silurian* are the names given to the early Paleozoic time periods represented by rocks in this area, including the Great Valley and Blue Mountain. (Rocks deposited in the Devonian through Permian Paleozoic Periods, which are exposed to the west of Blue Mountain, are not included on this chart.) The *Triassic* and *Jurassic* Periods are represented by rocks to the east of South Mountain in the Mesozoic Lowlands. Among the youngest materials in the region are the unconsolidated *Quaternary* surficial deposits that accumulated during the *Pleistocene,* the time period when glacial ice moved in and out of northern Pennsylvania.

Geologists use the term *formation* (fm.) as the basic unit in the classification of local rocks. Two or more formations may sometimes be combined to form a *group*. A *member* is a subdivision of a formation; usually it is of a more limited geographic extent. A *sequence,* as used here, refers to a unique assemblage of rocks that are bounded by faults and are not part of the normal stratigraphic succession for this area.

Formations, groups, and members are usually named after the place where they were first studied by a geologist, or sometimes after a place where there is an especially good exposure of the rocks that make up the unit. Local stratigraphic units include *Tuscarora* (after Tuscarora Mountain), *Juniata* (after the Juniata River), *Martinsburg* (after Martinsburg, West Virginia), and *Chambersburg* (after Chambersburg, Pennsylvania).

The *sawtooth line pattern* is used to represent an unconformity, which is a break or gap in the geologic record. It is added where the sequence of continuous deposition of rocks has been interrupted, usually because deposition at that point had ceased and erosion removed previously deposited material.

This column has been extracted and modified from the *Stratigraphic Correlation Chart of Pennsylvania* (Berg and others, 1983).

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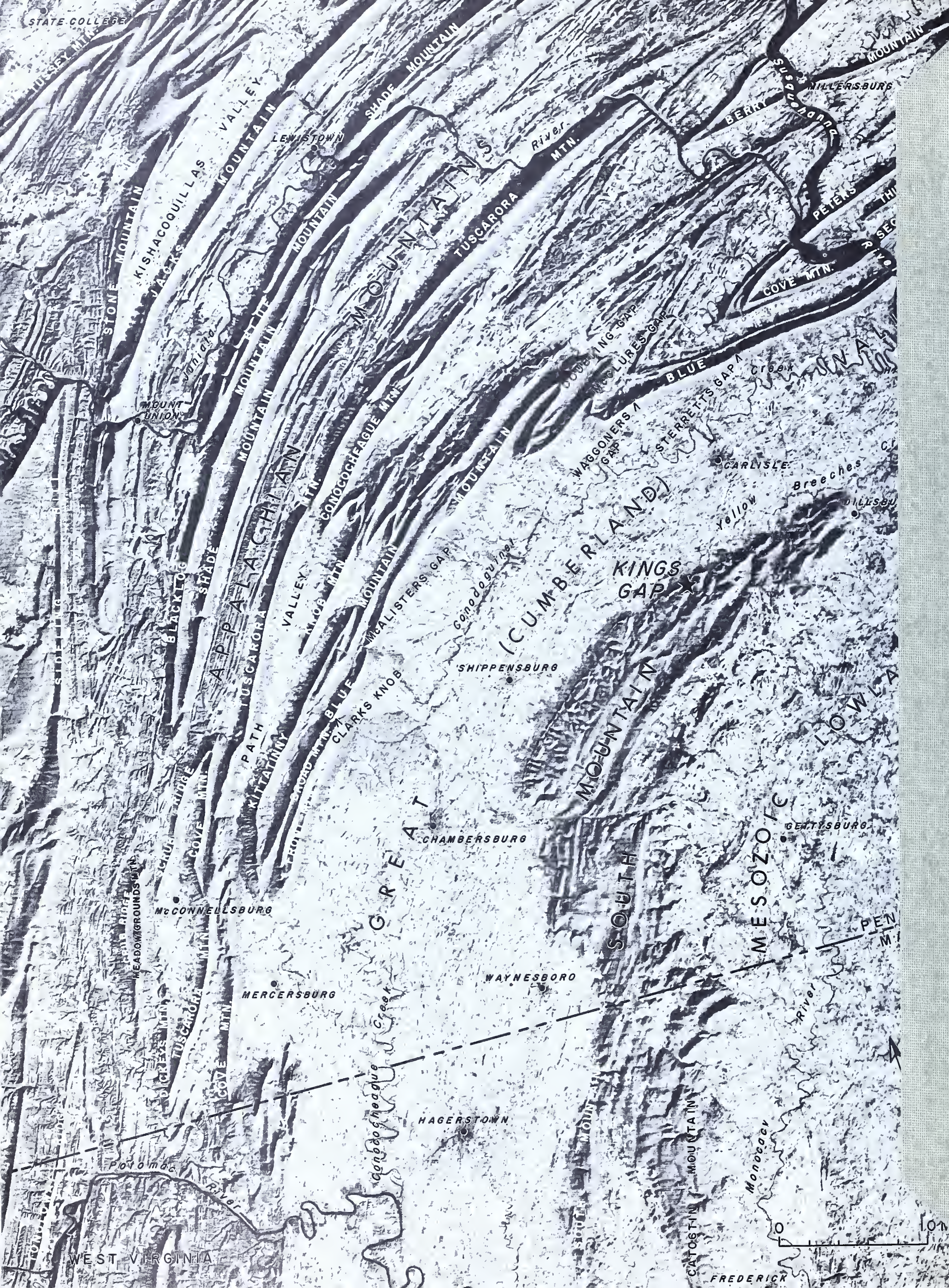
**BACK COVER:** High-altitude photograph showing the location of Kings Gap in relation to South Mountain and the surrounding physiography.



STATE COLLEGE
STONE MOUNTAIN
KISHACOQUILLAS VALLEY
JACKS MOUNTAIN
LEWISTOWN
SHADE MOUNTAIN
BLUE MOUNTAIN
TUSCARORA MTN.
River
APPALACHIAN
MOUNTAINS
MOUNT UNION
MILLERSBURG
BERRY MOUNTAIN
COVE MTN.
DOUBLING GAP
McCLURES GAP
STERRETTS GAP
WAGGONERS GAP
Creek
CARLISLE
Yellow Breeches
KINGS GAP
(CUMBERLAND)
CONOCOCHEAGUE MTN.
McALISTERS GAP
Conodoguinet
SHIPPENSBURG
CLARKS KNOB
TUSCARORA
PATH VALLEY
KITTATINNY MTN.
BLACKLOG
SIDELING HILL
MEADOW GROUNDS MTN.
McCONNELLSBURG
COVE MTN.
TUSCARORA MTN.
GREAT
CHAMBERSBURG
SOUTH MOUNTAIN
MESOZOIC
GETTYSBURG
WAYNESBORO
MERCERSBURG
Conococheague Creek
HAGERSTOWN
Potomac River
WEST VIRGINIA
CATOCTIN MOUNTAIN
Monocacy River
FREDERICK
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